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DERMATOME DÉBRIDEMENT AND EARLY GRAFTING OF EXTENSIVE THIRD DEGREE BURNS IN CHILDREN

IRVING A. MEEKER, JR., M.D., and WILLIAM H. SNYDER, JR., M.D., F.A.C.S.,
Los Angeles, California

ONE OF THE MOST TRAGIC and taxing surgical problems encountered today is that of the severely burned infant or child experiencing continuous pain and faced with an indefinite period of hospitalization. During the 18 months' period from September 1954 to April 1956, 13 such children with third degree burns covering 15 to 65 per cent of their total body surface were admitted to the Los Angeles Children's Hospital. In each patient the areas of full thickness burn injury were débrided, in stages, with an electric dermatome. Débridement was accomplished with a high degree of safety without incurring massive blood loss or inadvertently destroying viable skin. By employing this technique, it was possible to carry out extensive grafting at an earlier period in 1 or 2 major operations and to achieve major burn wound closure within 25 to 35 days following burn injury. Bacteriostatic dressings to control open wound infection were applied continuously throughout the period when multiple surgical procedures were being performed and until closure by grafting and epithelization was complete. The results obtained in the cases treated by this technique revealed that a very high percentage of grafts "took," resulting in a striking reduction in the number of operations and major burn dressings necessary before wound closure was achieved. In addition, the period of hospitalization was reduced in every case by more than 60 per cent, as compared with a group of 33 like patients treated in the same hospital (1951 to 1954), in whom burn slough was not surgically excised. In the light of these experiences it appeared worth while to present a survey of the problems and technical aspects in surgical management of these cases.

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This work was supported in part by grants from the Upjohn Company and Lederle Laboratories.

CLINICAL PROBLEMS

The introduction of plasma to combat shock and of appropriate electrolyte solutions to compensate for body fluid shifts has made possible great advances in the treatment of the acute phase of extensive third degree burns. Unfortunately, subsequent phases of burn therapy have changed very

little through the years. As a result, it has remained the accepted form of treatment to allow patients with extensive third degree burns, after being salvaged from shock, to remain swathed in bandages or permit their wounds to be exposed to the air for 3 to 5 weeks awaiting spontaneous separation and slough of burn eschar so that split thickness skin grafting could be undertaken.

Connor and Harvey attempted to shorten this interval by employing a chemical agent and Altemeier by using enzymatic agents in order to hasten burn tissue slough and thus permit early grafting, but these have not proved entirely satisfactory, particularly in extensive third degree burns. Surgical débridement has long been suggested, and has been attempted occasionally in recent years by Cope and Clarkson and their associates, but progress in this direction has been retarded because of the massive blood loss and shock generally accompanying such procedures and because of the danger of destroying viable skin, thought in error to have suffered full thickness burn injury.

In accumulating what is believed to be the first consecutive series of extensive third degree burn cases in children treated by surgical débridement, we have been able to avoid these particular hazards consistently by carrying out a series of staged surgical procedures in which the Brown electric dermatome (3) was used in exactly the same manner as skin grafts are cut from donor sites.

When a split thickness graft, no matter how thin, is removed from normal skin, multiple capillary bleeding points are noticed immediately. In contrast there is lack of bleeding when split thickness layers of skin are removed from areas of third degree burns. These simple observations form the basis upon which safe and satisfactory débridement can be carried out. Namely, lack of bleeding confirms the clinical impression that the area being bédrided is, in truth, avascular, necrotic, and has suffered full thickness injury. Thus, massive blood loss can be avoided and areas of viable skin can be detected promptly and living skin is not sacrificed inadvertently.

With this débridement technique we have found the wound may be prepared for closure split thickness grafts at least 1 to 3 weeks earlier than might be possible otherwise. This preparation can be completed during the period when as Sandblom has indicated, there is the greatest stimulus to wound healing, before homeostatic mechanisms have deteriorated and chronic wound infection and nutritional debilitation have rendered the patient a poor or even grave surgical risk.

Attempts at extensive one stage surgical excision to the full depth of the burn wound between the eighth and fourteenth days following injury, and after demarcation, are hazardous and may jeopardize the patient's life because of the massive blood loss secondary to débridement of the very vascular burn tissue underlying the skin.

Postinjury infection presents a serious problem with third degree burns. In the 13 cases reported herein, bacteriostatic dressings were applied routinely after each débridement and each grafting procedure. They were maintained continuously during convalescence, until burn wound closure had been achieved to combat the persistent hazards of local and systemic infection always present in extensive third degree burn injuries. For this purpose, tetracycline hydrochloride was selected because it is effective against a broad spectrum of gram negative and gram positive organisms. It is low in toxicity, has a low incidence of sensitization, and the stability at body temperature is prolonged. The intravenous form of tetracycline hydrochloride was used, 500 milligrams being diluted in 500 cubic centimeters of normal saline. Gauze rolls or squares were soaked in the solution and applied directly to the burn wound, providing a continuous topical bacteriostatic action. Occasionally this solution, in the same dilution, was injected through Dakin's tubes several times a day to enhance the effectiveness.

CLINICAL CASES

Of the 13 infants and children in this series who suffered extensive third degree burns, 7 were girls and 6 were boys. The mode of injury varied with the age and sex of the child. As a rule, the younger children (2 to 4 years), particularly girls, were burned while playing with matches which ignited their clothing (3 cases). In children 4 to 8 years of age, girls with flowing nightgowns or dresses were burned by backing into an exposed bathroom heater (2 cases), or when helping their mothers around the stove (2 cases). Boys of comparable age suffered injury while "stoking" an unguarded outdoor incinerator (2 cases). Finally, in children 8 to 12 years of age, the majority of burns were accounted for by boys playing with inflammable fluids in combination with fire in various forms (4 cases).

The sites of full thickness burn varied widely, depending upon the percentage of total body surface involved. Three children suffered 40, 50, and 65 per cent third degree burn injuries, respectively. In each instance the major portion of the trunk, both anteriorly and posteriorly, and 1 or more of the extremities were involved. Four children with 25 to 35 per cent full thickness burn injury had a significant portion of the upper, lower, anterior, or posterior trunk burned, as well as major segments of 2 or more extremities. Six children with 15 to 25 per cent third degree burn injuries had involvement of 1 or more extremities or the entire side of the trunk. We were fortunate in that only 1 patient in the series had third degree burns covering the entire face and neck. These 13 clinical cases were consecutive and unselected, without regard for the mode of injury, age of the patient, or the regions of the body burned. In short, no patient surviving the initial phase of shock was denied dermatome débridement and early grafting.

OBSERVATION OF THE WOUND

Immediately following burn injury in these patients, attention was focused upon preventing aspiration of gastric contents, maintaining an adequate airway, measuring urine output, combating shock with parenteral fluid administration, and providing adequate antibiotic coverage. The burned areas were left open to the air under a sterile sheet for frequent observation without disturbing the patient. During this period, lasting 2 to 4 days, the burn wounds were examined several times each day, to note particularly those areas in which the skin had a coagulated, egg-white, caseous appearance and did not blanch on pressure (Fig. 1). Such areas were further evaluated by scratching or incising them lightly with a sterile instrument to detect absence of bleeding and loss of sensation, indicative of third degree burn. Finally, the areas fulfilling these criteria were mapped out and plans for scheduled dermatome débridement and subsequent grafting were tentatively formulated.

DERMATOME DÉBRIDEMENT

Dermatome débridement was started shortly after the onset of massive diuresis, approximately the fourth or fifth day after burn injury. It was carried out under light anesthesia in 2 to 4 operations which were spaced 1 or 2 days apart. On each occasion the wound was thoroughly scrubbed with *p*HISODERM and 1:1000 zephiran.

For débridement the blade was set to remove a split thickness layer of skin approximately 10/1000 to 15/1000 of an inch in thickness. In areas of full thickness burn injury, no bleeding occurred when the first layers of burned skin were removed. Consequently, successive layers of nonviable skin and even avascular oily subcutaneous fat of similar thickness sometimes had to be excised before the first evidence of bleeding was encountered (Fig. 2). Thereafter, no further débridement was carried out in the area, even though it might be suspected that the eschar was actually deeper. Each area débrided was promptly dressed before attention was turned to other areas of full thickness burn requiring excision. A bacteriostatic pressure dressing was employed for

this purpose and consisted of a single layer of coarse mesh paraffin gauze applied directly to the freshly débrided wound. This was covered with multiple layers of heavy gauze dressings which had been soaked with tetracycline hydrochloride saline solution. These bandages were reinforced with moist sterile pads or waste material, and a circumferential pressure wrapping was applied.

Appropriate amounts of blood, approximately 5 to 10 cubic centimeters per pound, were administered through an inlying venous catheter as required during the operative procedure. Hemoglobin determinations were performed 4 and 8 hours after each débridement as a guide in determining blood replacement.

At subsequent débridement procedures a day or two later, frequently it was discovered that the extent of third degree burn areas had been underestimated and that there were new areas fulfilling the clinical criteria of full thickness burn injury which had to be débrided. The previously débrided areas were also examined to note any pinkness, blanching on pressure, or the presence or absence of multiple small bleeding points which are characteristic of a normal skin donor site a day or two old. In the absence of these findings such areas were once again subjected to dermatome débridement with excision being stopped when any *capillary* bleeding points were encountered. Most patients required 3 or 4 separate débridements during the first 10 to 14 days following burn injury to remove completely the burn eschar. The number of procedures necessary was determined by the depth of the burn, more specifically whether it involved only skin or extended down into the deeper subcutaneous fat layers.

TEMPORARY DELAY GRAFTING

Although grafting can be started as soon as mechanical débridement is completed, as suggested by Whittaker, in extensive third degree burns there is little or no margin for error in judging the readiness of an open wound for grafting. In short, a mistake in this regard results in the failure of grafts to take and the loss of a precious donor site. Consequently, it has been our policy to delay grafting until vascularity of the wound bed is assured. During this waiting phase the patient's débrided burn wound may be exposed regionally to determine which portion to graft first.

In burns which did not extend into the fascia and musculature the wound was ideal for grafting on or before the fourteenth day following injury, and in all cases large areas were prepared for grafting before the twenty-first day (Figs. 3 and 4). Once the operation was scheduled, all dressings were removed from the areas to be grafted 24 hours prior to surgery, and either multiple layers of gauze soaked in tetracycline hydrochloride and saline, as previously described, were applied to the granulating wound areas and changed every 4 hours, or a single dressing was employed and Dakin tubes were inserted and each irrigated with 60 cubic centimeters of this solution every 3 hours. Demerol was used to diminish pain.

SPLIT THICKNESS GRAFTING

Split thickness grafting of the major portion of the wound was planned in one or two stages. An attempt was made to cover up to 15 or 20 per cent of the total body surface at each operation. Such extensive surgical procedures have been well tolerated when carried out during the first 3 to 4 weeks following burn injury and are necessary if one is to take full advantage of the benefits of dermatome débridement and achieve early major burn wound closure.

The areas to be grafted were scrubbed with pHisoderm, water, and aqueous 1:1000 zephiran and were scraped lightly but thoroughly with a scalpel to débride any small bits of necrotic tissue and to reaffirm the presence of an adequate vascular granulating bed. Moist warm saline soaks were then applied to the wound for protection and hemostasis.

The Brown electric dermatome was set at 10/1000 to 12/1000 of an inch, and split

thickness grafts were removed commensurate with the area to be covered. When donor sites were limited and confined to areas presenting bony prominences such as the ribs, sacrum, and scapula a "push" clysis of 250 to 500 cubic centimeters of 2.5 per cent dextrose and water were given rapidly to elevate the skin away from these structures and permit excision of ideal grafts. Each donor site was bandaged with a pressure dressing as soon as the grafts were removed to prevent exposure to contamination, oozing, and blood loss. Blood replacement of 5 to 10 cubic centimeters per pound of whole blood adequately corrected blood losses incident to extensive graft excision. The split thickness portions of skin were fitted in place, with each member of the operating team being assigned an area to cover. Each graft was abutted to its neighbor graft when there was an adequate amount of skin for wound closure. If a patient had a third degree burn approaching or slightly in excess of 50 per cent of the body, sufficient donor sites were not available and grafts had to be placed ½ centimeter to 1 centimeter apart, in a giant "postage stamp" fashion. The grafts were not sutured in place at any point. Whenever practical the grafts were applied transverse to the long axis of the extremity or trunk in order to minimize the tendency for scar contracture formation. Finally the grafts were generously perforated or "pie-crusted" with scissors at approximately every centimeter to permit serum and blood drainage. To prevent sliding of the grafts, coarse mesh paraffin gauze rubbed and softened with a small amount of vaseline was applied directly to the grafted wound and smoothed down to adhere to the grafts, as advocated by MacCollum, then overlapped beyond the wound edges and "pasted down" to normal skin or ungrafted wound. Once again bacteriostatic pressure dressings were applied directly over the coarse mesh to help absorb the serum and blood seeping through the large openings of the mesh, and in turn provide continuous topical bacteriostatic effect. Additional moist waste material or padding was then employed to reinforce all grafted areas and maintain moisture in the antibiotic soaked gauzes.

IMMOBILIZATION

In burns involving the chest, abdomen, back, buttocks, and legs the patient was placed face up or down on a sponge rubber padded Balkan frame which had been covered with a thin sheet of polyethylene film. This position was maintained during the first 4 or 5 days after grafting so that nursing care could be carried out without moving the child. An indwelling urinary catheter was used to prevent soiling of the dressings. When the patient was in the face down position, the frame was bent approximately 10 to 15 degrees in its midportion for the patient's comfort and to straighten out creases in the buttocks where grafts had been applied. To prevent motion of the grafted extremities they were held with posterior molded plaster-of-paris splints.

In burns involving more than 60 per cent of the body, if all available donor sites have been exhausted, homografts, as described by Brown (2), may be considered in order to close temporarily the remaining granulating areas. However, in this series it was never necessary to employ homografts because a very high percentage of the split thickness skin grafts removed were successfully transplanted and healed without significant loss. When necessary, donor sites were reused after a period of 10 to 14 days.

POSTGRAFT CARE

Within 4 or 5 days after surgery, the dressings were removed and the grafted areas permitted to dry out beneath 4 or 5 single layers of tetracycline hydrochloride saline soaked gauze. The bandages were changed twice a day without causing great discomfort to the patient. Thus the wound was kept dry, clean, and devoid of the horny, dark, purulent crusts which form from the remaining ungrafted granulating areas when "open" treatment is employed. When a second major grafting is anticipated, if pos-

sible the first and second operations should be planned so the most recently grafted region, for example the trunk, may be exposed and dried in light thin bandages while the second area, such as 1 or more extremities, is being swathed in heavy moist graft dressings for an additional 4 or 5 days.

After the completion of the first or second extensive grafting procedure, major burn wound closure usually will have been achieved, the patient's temperature will fall to normal, his appetite will return, and his circulatory status will improve. The percentage of graft "takes" in the first and second graftings done during the first 30 days following burn injury was extremely high (Fig. 5) when this technique was used. In this series it has averaged over 90 per cent.

SUPPORTIVE THERAPY DURING WOUND CLOSURE

During the period of wound healing, broad spectrum systemic antibiotics were administered regularly, preferably by the parenteral route because of the frequent indefinite interruptions of oral intake through the period when intensive efforts were being made to débride, graft, and close the burn wound. Small volume whole blood transfusions were provided as needed in addition to those given during surgical procedures, since it is important to maintain the patient's hemoglobin at levels consistently above 14 grams. Food intake, as a rule, was poor as long as a major portion of the granulating wound remained open. Nevertheless, tube feedings were rarely used at this stage because of fear of aspiration in a seriously ill patient. Instead the patients in our series were offered an appetizing high calorie, high protein diet during the brief intervals between surgical procedures. Once major burn wound closure had been achieved, however, the patient's appetite returned and with an adequate caloric intake he began to gain weight and epithelization of his wounds occurred. In short, the previous negative nitrogen balance shifted to a positive nitrogen balance.

Tube feeding was resorted to only in the smaller children who could not be induced to eat at this time. Experience has indicated that far more effective than a gavage tube in these children may be a ride in a wheel chair, or a few proud painful steps, a friend's companionship in the next bed, and constant encouragement and admiration from the doctors and nurses who have been with them through their ordeal.

CONVALESCENCE

Seven to 10 days after the last grafting, if there had been an adequate caloric intake, the patient's wound was generally well enough epithelized between the graft margins so that dressings were no longer necessary. At this time the patient was gotten up, given warm baths twice a day during which all grafted and granulating areas were thoroughly soaked and gently scrubbed with gamophen soap. Thereafter, a thin film of vitamin A and D ointment was applied to the grafted areas and the patient needed only to wear a clean pair of pajamas or shirt over his residual areas of granulation tissue (Fig. 6). When the patient was discharged the family were instructed in home exercises and physiotherapy to maintain as full motion of the extremity as possible. Padded posterior molded splints were provided to be worn at night to lessen or prevent scar contractures which bridge the joints of extremities seriously affected by full thickness burn. Procedures to relieve scar contractures were delayed for at least 6 months to permit stretching and softening of the eschar, unless function of the part was seriously compromised.

RESULTS

The results in these 13 unselected extensive third degree burn patients are summarized in Table I. There has been but 1 death in this group, that of a 4 year old girl with third degree burns involving more than 60 per cent of her body surface. In this child it was possible to carry out successful dermatome débridement of the anterior chest and

upper abdomen, and to apply split thickness skin grafts to these areas within the first 2½ weeks following burn injury. The remainder of her third degree burn areas penetrated so deeply into the musculature of the back, thigh, flanks, and abdomen that deeper soft tissue débridement of these areas was necessary and grafting was delayed. Despite the successful grafting of her chest and abdomen, her general condition did not improve, the open wound area failed to granulate and she died suddenly during an episode of vomiting and aspiration shortly after a gavage feeding.

The remaining 12 patients are home, well, and actively playing or going to school. Of these, 9 with burns covering 15 to 40 per cent of their body were discharged from the hospital with their wounds débrided, grafted, and healed in less than 45 days. Two children required 50 and 52 days of hospitalization, respectively. Only 1 child was hospitalized for more than 60 days; in this case severe burns affecting the respiratory tract made general anesthesia unsafe and impractical for the first 11 days; consequently dermatome débridement had to be deferred.

A total of 69 surgical procedures under anesthesia, including all major burn dressings before wound closure, were required during the hospitalizations of these 12 surviving children, an average of less than 6 procedures for each of the patients in this series. It is believed that this marked reduction in the number of anesthetics administered and operations performed was due largely to the high percentage of graft "takes" obtained in these children. A total of only 22 grafting procedures were necessary in the patients. In this regard it is worthy of note that 6 children required only 1 extensive grafting to close the entire burn wound, 4 were grafted twice, and only 3 had to be grafted 3 times.

For the purpose of statistical comparison of these results with those obtained in the preceding years, the length of hospitalization was related to the per cent of burn wound grafted in an effort to measure the effectiveness of dermatome débridement and early grafting employed in these 13 patients, as compared with the effectiveness of treatment employed previously in a similar series of 33 patients who did not have mechanical removal of the slough but were treated by standardized techniques at the Los Angeles Children's Hospital between 1951 and 1954. This revealed that in the 12 surviving patients, here reported, an average of only *1.5 days* of hospitalization for each *1 per cent* of third degree burn grafted was required before wound closure and discharge from the hospital could be achieved. By contrast, in the comparable group of 28 surviving infants and children in whom débridement was not carried out, an average of *4 days* of hospitalization for each *1 per cent* of third degree burn grafted was required before burn wound closure and discharge from the hospital could be achieved.

Utilizing these figures of 1.5 days of hospitalization for each 1 per cent of burned body surface for the 12 living patients treated with the dermatome débridement technique, the following calculations are significant: $12 \times 28 \times 1.5 = 504$. In this formula, 12 equals the number of patients, 28 the average per cent per patient of body surface burned, 1.5 the number of days of hos-

TABLE I.—EXTENSIVE THIRD DEGREE BURNS TREATED BY DERMATOME DÉBRIDEMENT AND EARLY GRAFTING IN 13 CHILDREN

Case No.	*Sex*	*Age*	*Per cent of body burned*	*Hospital stay, days*	*Ratio* *Per cent*	*Days*
1	F	2 yr. 6 mo.	50	45	1	1
2	F	6 yr.	25	50	1	2
3	F	7 yr.	35	52	1	1.5
4	F	3 yr. 8 mo.	20	30	1	1.5
5	M	10 yr. 8 mo.	40	40	1	1
6	M	5 yr. 9 mo.	35	65	1	1.8
7	F	7 yr. 7 mo.	30	40	1	1.3
8	F	4 yr. 6 mo.	(65)	(21)	Expired	
9	F	2 yr. 9 mo.	20	23	1	1
10	M	7 yr. 8 mo.	15	30	1	2
11	M	12 yr. 4 mo.	15	30	1	2
12	M	4 yr. 6 mo.	25	36	1	1.4
13	M	6 yr.	25	34	1	1.3
Average		6 yr. 2 mo.	28	40	1	1.5

In the column on the right, the area involved in a third degree burn is compared with the number of days of hospitalization. Thus, if 20 per cent of the body surface was involved in a third degree burn and the child required 20 days of hospitalization before burn wound closure and discharge was achieved, the ratio would be 1:1. It is hoped that this method of measuring the results of burn treatment will be utilized by others.

pitalization required for each 1 per cent of surface area burned and 504 the total number of hospital days required for the group. Utilizing the same formula for 12 patients treated before the adoption of the dermatome débridement technique, we have $12 \times 28 \times 4 = 1{,}344$. If we then subtract 504 (the days required under the present treatment) from 1,344 (the days required under the previous treatment), we find that 840 days or 2.3 years of hospitalization have been saved in this small group of burned patients. From a financial standpoint this means a saving of approximately $32.00 a day for 840 days, or $26,880 for these 12 patients.

Financial savings would mean nothing if it were not apparent from observing the patients treated by the proposed method that their recoveries were more assured, more satisfactory, and more complete. It is our firm belief that the objectives sought in this speeded up program of burn management have in a large measure been achieved.

SUMMARY

A new technique of dermatome débridement to remove burn eschar in extensive third degree burns permitted early grafting and more rapid wound closure and resulted in a more than 60 per cent reduction in the length of hospitalization. This was achieved without incurring massive blood loss or inadvertently destroying viable skin, as has occurred with other forms of surgical débridement. To protect against serious wound infection, bacteriostatic dressings employing tetracycline hydrochloride were applied continuously during all phases of treatment until complete epithelization of the wound had taken place.

The results in this series indicate that it is practical to manage major third degree burn injuries from the onset by a series of planned, staged, surgical procedures involving dermatome débridement and subsequent early extensive grafting. Dermatome débridement has proved to be a safe, satisfactory technique for removing extensive burn eschar. When such débridement is followed by early extensive grafting the pain and suffering the patient experiences is immeasurably reduced, the responsibility for patient care imposed on the hospital and its surgical and nursing staff is eased, and the period of hospitalization necessitated by the operative procedures which are required to achieve burn wound closure is shortened by many weeks and in certain instances by several months.

Specifically, in comparing 12 cases of severe burns treated with early dermatome débridement with their equivalent treated by standard methods, 840 days or 2.3 years of hospitalization were saved. The plan of treatment outlined in this presentation is enthusiastically advocated for improving the management of severe burns.

REFERENCES

1. Altemeier, W. Enzymatic débridement of burns. Ann. Surg., 1951, 134: 581.
2. Brown, B. J., Fryer, M. P., and Zaydon, T. J. A skin bank for postmortem homografts. Surg. Gyn. Obst., 1955, 101: 401.
3. Brown, H. M. A motor driven dermatome. Indust. M., 1948, 17: 46.
4. Clarkson, P., and Reid, D. C. Use of the electrodermatome, with special reference to its value in serious burns. Brit. M. J., 1953, No. 4839, Oct. 3.
5. Connor, C. J., and Harvey, S. G. The pyruvic acid method in deep clinical burns. Ann. Surg., 1946, 124: 799.
6. Cope, O., Langohr, J. L., Moore, F. D., and Webster, R. C., Jr. Expeditious care of full thickness burn wounds by surgical excision and grafting. Ann. Surg., 1947, 125: 1.
7. MacCollum, D. W. Personal communication.
8. Sandblom, P. Effect of injury on wound healing. Ann. Surg., 1949, 129: 305.
9. Whittaker, A. H. Treatment of burns by excision and immediate skin grafting. Am. J. Surg., 1953, 85: 411.

PERICARDIECTOMY FOR CHRONIC IDIOPATHIC PERICARDITIS WITH MASSIVE EFFUSION AND CARDIAC TAMPONADE

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RECENT PUBLICATIONS have called attention to the occurrence of chronic idiopathic pericarditis with massive effusion and cardiac tamponade. They have pointed out that this condition may exist for long periods of time and may eventuate in chronic constrictive pericarditis. Its early management by extensive pericardiectomy is a relatively new concept. It is the purpose of the present report to describe 2 cases successfully managed in this manner and to review the literature briefly.

CASE REPORTS

CASE 1. The patient was a 16 year old school girl who was admitted to the hospital on August 16, 1955. She had been entirely well until 9 months before admission when she fainted while dancing. Episodes of syncope occurred several times a week during the following 2 months, usually following physical education classes. Seven months before admission she developed low grade fever, dyspnea, a feeling of fullness in the chest and neck, a dull, aching pain in the lower anterior portion of the left chest, and swelling of the face, hands, feet, legs, and abdomen. On admission to another hospital she was noted to be orthopneic and cyanotic. There was flatness over the left lower lung field posteriorly. The heart sounds were distant. No murmurs were heard. The liver was considerably enlarged. Roentgenograms revealed a markedly enlarged pericardium. Blood counts and urinalyses were within normal limits, porphyrin studies were negative and serum cholesterol was 147 milligrams per cent. The sedimentation rate ranged between 36 and 42 millimeters. No lupus erythematosus cells were seen in the blood smears. Low voltage was noted on the electrocardiographic tracings. The first and second strength Mantoux tests were negative, as was the histoplasmin test. It was apparent that she had cardiac tamponade, and pericardiocenteses were performed on January 22, 23, and 24, the total amount of fluid removed being over 2 liters. Protein and acid-fast cultures of the pericardial fluid were negative. The signs of tamponade and congestive heart failure rapidly subsided. She was treated with digitalis, diuretics, and achromycin and was discharged after a month's hospitalization.

Her progress was fairly good for the next 2 months and then she was readmitted to the hospital 1 month later because of increasing dyspnea on exertion and a feeling of fullness in the epigastrium. Again the heart tones were distant and the liver was enlarged. There was no peripheral edema. The blood pressure was 98/80. Serum cholesterol was normal, the C-reactive protein negative, and the sedimentation rate 20 millimeters. Pericardiocentesis was performed and 2,050 cubic centimeters of fluid were removed. The blood pressure then stabilized at about 100/60. The patient lost 8 pounds in weight and the hepatic enlargement subsided. The pericardial fluid removed contained 3 lymphocytes per cubic millimeter and 6.1 grams of protein. Smears were negative for tumor cells. The patient improved rapidly and was discharged from the hospital. Symptoms soon returned and pericardiocentesis was again necessary in July. On this occasion 2,500 cubic centimeters of fluid were removed.

On admission to our hospital in August, the patient's heart tones were muffled, there was a flat percussion note over the left base posteriorly, and the blood pressure was 100/65. Roentgenograms demonstrated a huge pericardium with an air fluid level (Fig. 1a). The electrocardiograms revealed a low voltage. Blood count and urinalysis were normal. On August 17 an extensive pericardiectomy was performed through a median stenotomy incision. As soon as the pericardium was removed the heart function improved remarkably. The excised pericardium was thickened, weighed 115 grams and measured approximately 15 by 18 centimeters in size. It was approximately 3 millimeters thick. Histologic study revealed evidence of chronic, nonspecific pericarditis. Postoperative progress was good and she has remained entirely well. Roentgenograms of the chest 4 months after operation showed a normal cardiac contour (Fig. 1b).

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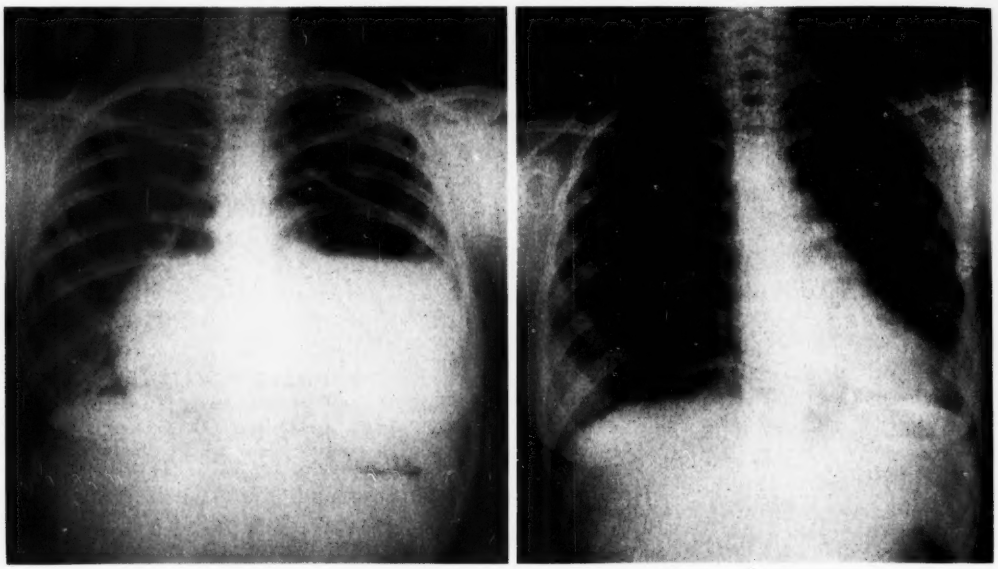

a b

FIG. 1. Preoperative and postoperative roentgenograms of the chest in Case 1.

CASE 2. The patient was a 53 year old white paranoid male who was admitted to the hospital as a transfer from a state mental institution on October 10, 1955. A reliable history could not be obtained but the patient had apparently been known to be hypertensive for several years. For approximately 9 years he had suffered from some discomfort in the epigastrium, associated with intermittent eructation and vomiting which bore no relationship to meals and was not associated with melena, hematemesis, jaundice, or change in bowel habits. He had been placed on digitalis some time prior to admission and on a salt-poor diet. Roentgenograms made in another hospital 22 months prior to admission revealed a massive enlargement of the cardiac silhouette compatible with pericardial effusion.

On examination the heart sounds were distant and no murmurs were heard. There was dullness to percussion and diminished breath sounds anteriorly in both lung fields. The veins were distended and the liver enlarged. There was pitting peripheral edema and obvious ascites. The blood pressure was 210/120 and the cardiac rhythm and rate were normal. Funduscopic examination showed arteriosclerotic retinopathy. X-ray films of the chest demonstrated a greatly enlarged cardiac shadow (Fig. 2a). The electrocardiogram did not reveal particularly low voltage. First strength Mantoux and histoplasmin tests were negative. The second strength Mantoux test was, however, strongly positive. Arm-to-tongue circulation time was 20 to 25 seconds and the venous pressure was 25 centimeters of water. Kidney and liver function tests were within normal limits. The regitine test was negative. Serum cholesterol was 123 milligrams per cent. Blood counts and urinalyses were normal. A pericardiocentesis was performed with the removal of thick yellow fluid with a specific gravity of 1.026, an occasional white blood cell, albumin 3.58 grams per cent, globulin 2.72 grams per cent, calcium 8.8 milligrams per cent, chloride 98 milliequivalents, sodium 134 milliequivalents, supernatent cholesterol 78 milligrams per cent, and cholesterol sediment (crystals) 1,000 milligrams per cent. Cytologic studies showed many histiocytes and clusters of mesothelial cells, but no tumor cells were seen.

On August 27, 1955, an extensive pericardiectomy was performed through a median stenotomy incision. The heart function was excellent as soon as the pericardium was removed. The pericardial sac contained over 3 liters of fluid. The excised specimen consisted of two sheets of pericardium, one measuring 15 by 12 centimeters in size, the other 14.5 by 11 centimeters. It was about 2 millimeters in thickness. On microscopic examination there was evidence only of chronic, nonspecific pericarditis. The patient had an uneventful convalescence except for a transient bout of auricular fibrillation. Postoperatively the arm-to-tongue circulation time was 22 seconds and the venous pressure 7.6 centimeters of water. The ascites and peripheral edema disappeared and the liver became considerably smaller in size. The patient has remained remarkably improved and states that he feels better than he has for many years. Roentgenograms reveal marked diminution in heart size (Fig. 2b). His hypertension persists and on occasions he has a few rales and

a b

FIG. 2. Preoperative and postoperative roentgenograms of the chest in Case 2.

a trace of pretibial edema, signs believed to be due to his hypertensive cardiovascular disease.

DISCUSSION

Both acute and chronic pericarditis may be caused by a variety of infectious processes, metabolic disorders, and physical agents. In a large proportion of cases of pericarditis with or without effusion, no specific etiology can be determined. It has long been recognized that pericardial effusion frequently occurs in acute pericarditis. Recently Barker and Johnston and Silverstone have called attention to the fact that chronic pericarditis with effusion may be present for long periods of time. Usually this condition is attended with evidences of chronic cardiac tamponade. Often the cardiac tamponade is of far greater importance than the underlying disease of the pericardium. Cardiac constriction may result not only from the massive effusion but from thickening of the underlying visceral pericardium as well. Just as is true in the case of tuberculous pericardial effusion, chronic idiopathic pericarditis with effusion may eventuate in chronic constrictive pericarditis. Long continued constriction of the heart may result in atrophic changes and permanent circulatory damage to the myocardium. Chronic pericardial effusion has been treated by multiple paracenteses, and in 3 instances (cases of Silverstone, Field, and Proudfit and Effler) treatment was by pericardiopleural fenestration. One of these patients had a good result during a very brief follow-up period. The second had a good clinical result during a follow-up period of over 6 years, though there was x-ray evidence suggesting the presence of some residual pericardial fluid. The third also did well. The length of follow-up was not stated.

A very significant advance was made in 1951 by Holman and Willett who pointed out the desirability of proceeding with pericardiectomy in cases of tuberculous pericarditis with clinical evidence of cardiac tamponade regardless of tuberculous activity. They demonstrated that pericardiectomy could be performed with minimal risk and that, with the use of antituberculous drugs, there was little likelihood of spread of the tuberculous process. They called attention to the fact that pericardiectomy carried out in the stage of effusion could be performed

TABLE I.—CASES OF IDIOPATHIC CHRONIC CONSTRICTIVE PERICARDITIS WITH CARDIAC TAMPONADE TREATED DURING THE STAGE OF EFFUSION BY PERICARDIECTOMY

Author	*Age of patient, years*	*Sex*	*Duration of symptoms*	*Result*	*Length of follow-up period*
Yu	70	M	1 year	Good	1 year
Rabiner	40	M	3 months	Good	1½ years
Mannix	41	M	7 months	Good	5 months
Mannix	43	F	4 months	Good	1½ years
Mannix	45	M	4 years	Good	2 years. Died 2 years later, cause of death unknown
Authors	16	F	7 months	Good	10 months
Authors	53	M	2 years	Good	8 months

much more easily than in the stage of constrictive pericarditis. This concept has recently been extended to the management of cases of chronic idiopathic pericarditis with effusion and cardiac constriction (Table I). Yu and his associates obtained an excellent result in a 70 year old man who had had symptoms for approximately 1 year. Rabiner and his colleagues also secured a very good result in a patient whose symptoms were of several months' duration. Five of the 6 patients described by Mannix and Dennis had idiopathic pericarditis with effusion and 3 of them were operated upon during the stage of effusion with excellent results. The other 2 were treated surgically later during the phase of constrictive pericarditis. Good results were obtained in these cases as well. The 3 patients of Barker and Johnston were all operated upon late in the course of their disease when constrictive pericarditis was present and the results were rather poor. Excellent results were also obtained in our own patients, 1 of whom was operated upon relatively early and the other considerably later, but still while in the stage of effusion.

It seems clear that patients with chronic idiopathic pericarditis with massive effusion and cardiac tamponade should be treated surgically at an early date. Though the 3 reported cases treated by pericardiopleural fenestration did well, it is our feeling that extensive pericardiectomy is the preferable procedure. The operation is technically easy and the entire anterior and lateral surfaces of the pericardium can be excised with facility. Such treatment removes the major portion of the primary disease. It brings to an early end the disabling consequences of cardiac constriction. It prevents the long continued tamponade with its potentials for permanent myocardial damage. It eliminates the necessity of performing pericardiectomy later during the phase of constrictive pericarditis when the operation is technically more difficult and somewhat more hazardous. Excellent results have been obtained in the 7 recorded instances in which this operation has been carried out during the stage of effusion.

SUMMARY

Two cases of chronic idiopathic pericarditis with massive effusion and cardiac tamponade treated by extensive pericardiectomy are reported. The pertinent literature is reviewed. Extensive pericardiectomy is recommended as the procedure of choice in cases of chronic pericarditis with effusion and evidences of tamponade.

REFERENCES

1. Barker, P., and Johnston, F. Pericarditis with effusion. Circulation, 1950, 2: 134.
2. Field, R. A. Editor, Medical grand rounds. Am. Practitioner, 1953, 4: 475.
3. Holman, E., and Willett, F. Treatment of acute tuberculous pericarditis by pericardiectomy. J. Am. M. Ass., 1951, 146: 1.
4. Mannix, E. P., and Dennis, C. Surgical treatment of chronic pericardial effusion and cardiac tamponade. J. Thorac. Surg., 1955, 29: 381.
5. Proudfit, W. L., and Effler, D. B. Diagnosis and treatment of cardiac pericarditis by pericardial biopsy. J. Am. M. Ass., 1956, 161: 188.
6. Rabiner, S. F., Specter, L. S., Ripstein, C. B., and Schlecker, A. A. Chronic constrictive pericarditis as sequel to acute benign pericarditis. N. England J. M., 1954, 251 (11): 425.
7. Silverstone, F. A. Recurrent heart failure with tamponade due to pericardial effusion. Ann. Int. M., 1955, 42: 937.
8. Yu, P. N. G., Lovejoy, F. W., Joos, H. A., Meyer, R. E., and Simpson, J. H. An unusual case of massive pericardial effusion with hemodynamic studies. Ann. Int. M., 1953, 39: 928.

EXPERIMENTAL STUDIES ON INTERSTITIAL INJECTION OF RADIOACTIVE COLLOIDAL GOLD (AU^{198})

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THE CURE OF METASTATIC CANCER is a major challenge to modern medicine. Because the etiology is unknown, we have been forced to treat cancer with only limited success, by surgical extirpation, radiation therapy, or a combination of the two. Under trial are various chemicals, but the results have not been encouraging. Early diagnosis and destruction of the primary tumor and the immediate lymphatics constitute the rational limits of ideal modern therapy. If improvement in survival is to be achieved the diagnosis must be made more promptly, the surgery must be more radical, and radiation therapy more effective. New modalities of therapy are objects of a never ending search.

Until recently, the practical application of radiant energy as a therapeutic agent has been limited to the use of gamma rays and x-rays. Distinguishable only by their source, gamma rays and x-rays are electromagnetic radiations with a very short wave length and of the same species as visible light and wireless waves. They travel with the speed of light and are neither deflected by electric nor magnetic fields. Gamma rays originate in the atom's nucleus while x-rays are extranuclear. For purposes of energy interchange with atoms, x-rays, and gamma rays have been regarded as bullet-like particles or quanta. These quanta, or photons, may be considered to be discrete and localized bundles of electromagnetic energy. They have zero cell mass.

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In radiologic therapeutics, the penetrating power is known to vary inversely to the wave length: the shorter the wave length, the greater the penetrating power. The tumorocidal effect of gamma and x-rays is dependent upon tissue ionization and secondary electron emission. The limit of tolerance of normal tissue to externally applied gamma rays and x-rays has been the oncologist's chief therapeutic barrier. Efforts and methods to circumvent these shortcomings have led to the development of supravoltage x-ray machines and the substitution of radioactive cobalt as the source of radiant energy. Unfortunately, the cancerocidal dose of external radiation may result in overradiation to adjacent normal tissues. Although improvement has been considerable, the ability safely to deliver cancerocidal doses of gamma rays and x-rays to cancer-bearing tissues deeply located within the body has not been sufficiently improved to satisfy the extended severe and critical demands of metastatic malignant spread.

With the development of the pile as a source of radiant energy characterized by intense neutron flux, a large number of beta emitting radioactive isotopes have become available for therapeutic evaluation. Radioactive colloidal gold has been used with considerable frequency, and its empiric record has been encouraging.

Its physical form and cancerocidal potentialities combine to make the use of colloidal radioactive gold by interstitial injection most attractive. The beta radiation, available with radioactive colloidal gold,

is a new modality of radiation therapy when contrasted with the mechanism for x-ray and gamma ray therapy. The principle of supplying the tumor and the immediate lymphatics with high energy beta radiation, the effectiveness of which is chiefly dissipated within .5 millimeter of tissue penetration, is quite different from the external application of gamma ray and x-ray radiant energy in which the effectiveness is proportionately diminished by the linear distance and the intervening thickness of body tissue.

Radioactive colloidal gold possesses certain interesting properties:

1. Ninety-five per cent of the tissue ionization produced originates with the beta radiation. Radiation consists of 3 beta and 3 gamma rays. The 0.290 million electron volts of gamma and 0.963 million electron volts of beta make up about 99 per cent of the decay scheme.
2. The maximum range of the 0.963 million electron volts of beta radiation is 3.8 millimeters in tissue.
3. The colloidal particles are eagerly injested by macrophages.
4. It deposits itself rapidly and uniformly upon serosal surfaces.
5. The colloidal gold particles are basically inert.
6. It can be used intravenously without fear of embolic phenomena because the particle size averages about 5.0 millimicrons.
7. The associated gamma ray serves as a convenient means of identification and, in addition, affords some therapeutic benefit.
8. The half-life is 2.69 days and 94 per cent of the radiation dose is delivered within the first 11 days.
9. It possesses a deep cherry red color for identification.
10. It can be shipped in special glass bottles for assurance of sterility.
11. One millicurie spread over 1,000 square centimeters gives a calculated dose of 900 roentgens equivalent physical to the area.

Radioactive colloidal gold, as a trillion point source of beta radiation, has had increasing clinical use for the treatment of human malignancy. Before its general use can be adopted, certain basic facts must be established. The limitation of effectiveness and margin of safety must be anticipated. Once the solution is injected into the tissues, it is important to know if the injection bolus remains pooled or if it is dispersed; if it remains pooled at the site of injection, is the time interval sufficiently long to cause severe local radiation reactions; if the solution is quickly dispersed, is the route of egress by way of the lymphatics or the blood stream; if the radioactive colloidal gold reaches the regional lymphatic glands, is the concentration and time interval favorable to the production of adequate radiation effects; if the solution gains access to the blood stream, are adverse radiation effects evident in the parenchyma of distant organs, i.e. liver, kidney, and spleen. These and other questions concerning the ideal dose per gram of tissue, the concentration of radioactivity in the injectate, the necessity for precise injection of the solution, the mobility from lymph glands, and the ultimate disposition by body tissues of the gold colloid pose interesting and challenging problems of clinical importance.

PROCEDURE

The following protocol for laboratory investigation was adopted. Rabbits weighing between 3,600 and 4,500 grams were used. The site selected for injection was the left inferior thoracic mammary gland. Injections were made under sodium pentothal anesthesia. The breast areas were shaved and painted with 1 per cent hexachlorometacresol solution.

The project was divided into three phases. The first phase was characterized by the injection of 4 per cent direct sky blue colloidal dye solution; the second phase, by injection of nonradioactive colloidal gold solution with and without hyaluronidase solution; and the third, by injection of Au^{198}.

Phase 1.0—Injection of 4 per cent direct sky blue dye

To determine the anatomic distribution of colloidal solutions injected into the left inferior thoracic mammary gland of rabbits, 5 cubic centimeters of direct sky blue dye were used. Hyaluronidase, 50 units, was admixed with the injectate in some experiments. At intervals of 10, 20, 40, 60, and

120 minutes the animals were sacrificed and radical lymph node dissection accomplished. Four rabbits were used for each time unit.

Results. The time limit for gross visible staining of the regional lymph nodes was: 10 to 20 minutes for homolateral axillary lymph nodes, 20 to 60 minutes for internal mammary chain (bilateral), 40 to 60 minutes for contralateral axillary lymph nodes. All regional lymph nodes were adequately stained within the 60 minute postinjection period. Dye was identified in the left axillary, left internal mammary, the right axillary, right internal mammary lymph glands as well as in the corresponding breast on the opposite side.

This information was important, because rapid and deft handling of the tissues following the injection of radioactive colloidal gold was necessary to protect the personnel from excessive radiation. Identical results were observed following injection of 1 per cent trypan blue dye.

Phase 2.0—Injection of nonradioactive colloidal gold

Sixteen rabbits were used to determine the speed of transport of nonradioactive colloidal gold solutions. The total volume of the injectate was 11 cubic centimeters and contained nonradioactive colloidal gold in the same concentrations as were used in experiments with radioactive colloidal gold. Hyaluronidase, 50 and 100 units, was used in half of the experiments. The animals were sacrificed at 6, 12, 24, and 48 hours because it was discovered that colloidal gold did not migrate to the regional lymph nodes with the rapid speed of the dye.

Results. The time of identification of the colloidal gold, nonradioactive, in the regional lymph nodes was: 12 to 24 hours for the homolateral axillary lymph nodes, 16 to 24 hours for the internal mammary chain (bilateral), 16 to 24 hours for the contralateral axillary. No difference was noted from the use of hyaluronidase and its further use was abandoned. The same lymph glands were involved with colloidal gold as were stained with direct sky blue dye. The rate of transport of colloidal gold was considerably slower than occurred with the use of direct sky blue dye. The reason for the delay in mobilization of colloidal gold has not been determined. Colloidal gold does not diffuse throughout the body tissues as do the electronegative dyes of smaller particle size. It tends to remain localized to the site of injection and regional lymphatics.

Phase 3.0—Injection of radioactive colloidal gold

This phase of the experiment was divided into two parts to be designated 3.1 and 3.2. The phase 3.1 was accomplished with tracer doses and was concerned with the rate and pattern of migration of colloidal gold from the site of injection. By using radiation assay methods the concentration of the total injected volume trapped in any set of lymph glands could be calculated. This observation when correlated with the postinjection time interval provided dynamic information of the mobilization profile. These observations were correlated with the second part (phase 3.2) in which therapeutic doses of radioactive colloidal gold ranging from 1 to 2 millicuries per gram of breast tissue were injected. Histologic response to the radiant energy of radioactive colloidal gold was evaluated by micropathologic methods.

The technical procedures for both parts of phase 3.0 were essentially identical and will be described jointly. The radiant activity of the isotope solution when received averaged 20 to 40 millicuries per cubic centimeter. This preparation was appropriately diluted with isotonic sodium chloride solution to average 0.023 to 0.18 millicuries per cubic centimeter for the tracer studies and to 1 and 2 millicuries per cubic centimeter for the studies on therapeutic doses.

The rabbits were sacrified at appropriate intervals. The desired tissue was removed after careful dissection, cleaned of extraneous material, weighed, and stored under deep freeze conditions until assayed.

The specimens removed consisted of the injected left breast and overlying skin, the

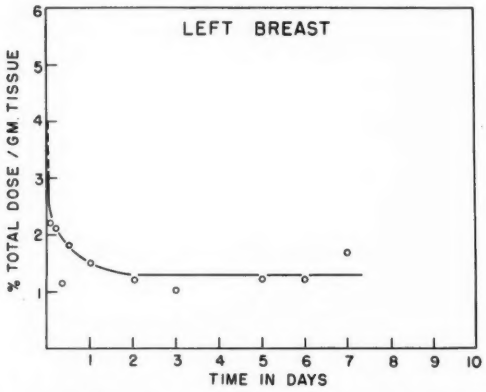

FIG. 1. Rate of migration of gold colloid from the left breast.

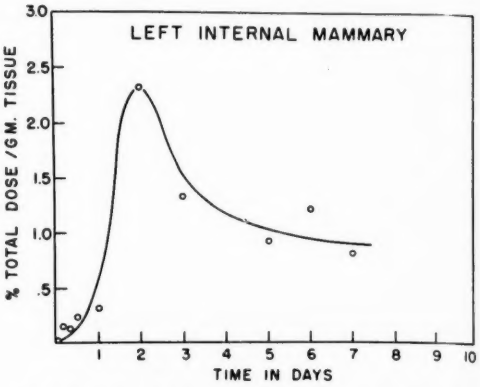

FIG. 3. Rate of migration of gold colloid from left internal mammary nodes.

corresponding right breast, and left and right axillary and internal mammary lymph glands, the liver, spleen, and kidneys. The data reported were obtained from samples prepared by a technique devised in the Department of Physics, Edsel B. Ford Institute for Medical Research, by one of us (L.E.P.).[1]

When ready for assay, the tissues were macerated in 2 cubic centimeters of 5 per cent potassium hydroxide solution and heated in a water bath to just below the boiling point for 30 to 60 minutes. When cool, the partially digested specimen was neutralized with 23 cubic centimeters of 6 times normal solution of hydrochloric acid. The specimen was triturated in a tissue mortar until a fine suspension was obtained. The volume was then raised to 10 cubic centimeters by the addition of isotonic sodium chloride solution. One cubic centimeter of the aliquot was obtained for determination of radiant activity.

[1]Paper in preparation.

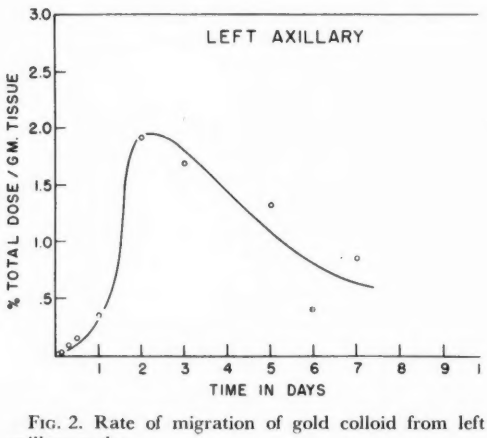

FIG. 2. Rate of migration of gold colloid from left axillary nodes.

When the specimen was of large size, such as breast tissue, it was cut into small pieces and liquefied in a blending machine. After adjustment of the volume, 1 cubic centimeter of aliquot was removed for assay.

Assay of the tissue aliquots was made against the original radioactive colloidal gold solution which was used for injection of that particular animal. After suitable dilution, a 1 cubic centimeter of aliquot, plus 0.1 cubic centimeter of distilled water was used for the counting reference, thereby making corrections for Au^{198} decay unnecessary.

All samples, including the standard, were contained in 4 cubic centimeter stoppered vials and assayed by the well type scintillation crystal counter.

The colloidal radioactive gold tissue concentration was calculated by means of the simple relation:

$$\text{Per cent of total dose/gram specimen} = \frac{Ct}{Cs} \cdot \frac{Dft}{Dfs} \cdot \frac{100 \text{ per cent}}{Vd\ Wt}$$

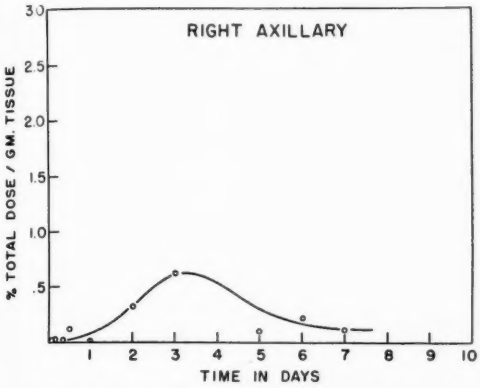

FIG. 4. Rate of migration of gold colloid from right axillary nodes.

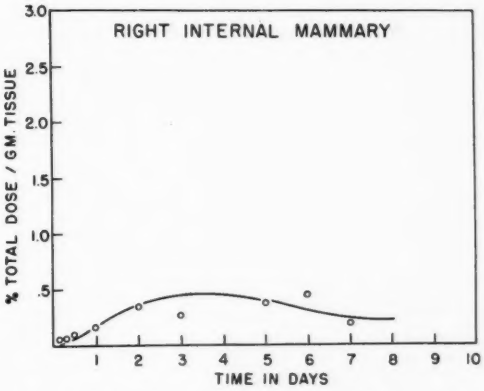

FIG. 5. Rate of migration of gold colloid from right internal mammary nodes.

where

Ct is the corrected count of the tissue specimen
Dft is the dilution factor for specimen preparation
Cs is the corrected standard count
Dfs is the dilution factor for the standard
Vd is the dosage volume
Wt is the specimen weight in grams

All results are expressed in terms of per cent of the total tracer dose found per gram of tissue in question assayed.[2]

Phase 3.1—Tracer studies Au^{198}. A minimum of 3 animals were used for each of the following sacrifice time intervals: 1, 4, 8, 12, 24, 48, 72, 120, 144, and 168 hours. After appropriate dilution of the radioactive gold solution to volumes ranging in radiant activity from 0.023 to 0.18 millicuries per cubic centimeter, the left inferior thoracic mammary gland of a rabbit was injected with volumes calculated as 1 cubic centimeter per gram of breast tissue. The animals were observed to be free of evidence suggestive of radiation toxicity. None of the animals failed to survive the appointed time.

Results. The concentration of gold in the various tissues, expressed as percent total dose per gram of tissue, was plotted against time. The initial transport of the gold colloid from the breast was very rapid. The rate of migration can be evaluated by observation of Figure 1. The plots shown represent mean values for 3 animals sacrificed. At time zero the specific concentration was approximately 10 per cent. The concentration fell to approximately 2.0 per cent in 2 hours, 1½ per cent in 24 hours, and asymptotically leveled off in 2 days at approximately 1.2 per cent. Thus, more than 80 per cent of the dose left the breast in 48 hours. This extremely rapid migration of the gold from the breast is fortuitous because of the relatively short half life of the isotope.

The early transport of the isotope from the breast was reflected in the percentage of specific concentration build-up in other tissues. The curves obtained from analysis of the left axillary (Fig. 2) and the left internal mammary nodes (Fig. 3) were quite similar.

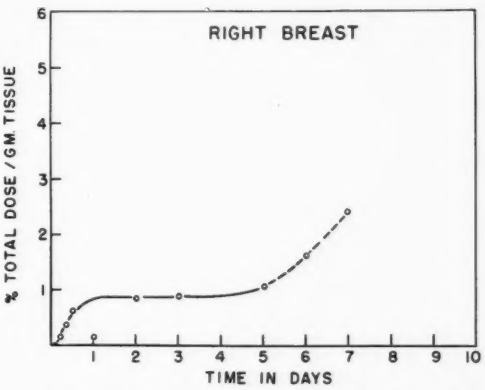

FIG. 6. Rate of migration of gold colloid from right breast.

[2] Referred to hereafter as percentage specific concentration.

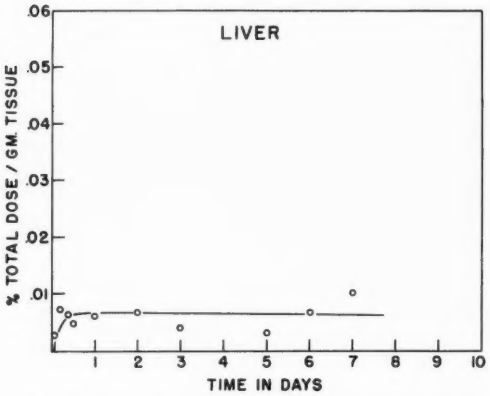

FIG. 7. Graph from data obtained from assay of the liver.

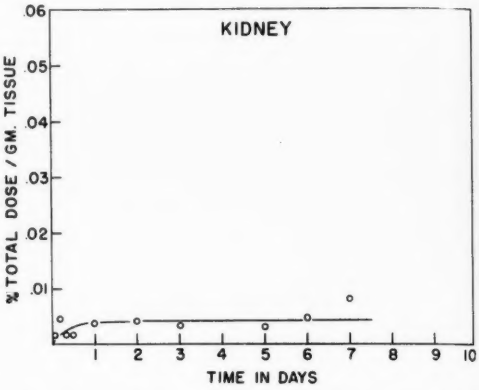

FIG. 9. Graph from data obtained from assay of the kidney.

Both exhibited a peak concentration of 2 per cent specific concentration for the left axillary and 2.4 per cent specific concentration for internal mammary nodes which occurred approximately 48 hours after injection of the ipsilateral breast. Following the maximum concentration, the curve fell off rather rapidly and approached a constant level within approximately 7 days. The so-called "peaking effect" implied that all of the gold particles do not remain in the first node during the course of migration. The migration to secondary nodes is advantageous, since all of the radioactivity is not spent in the first lymph node. It would seem that colloidal gold behaves in a manner similar to that of metastatic cancer itself.

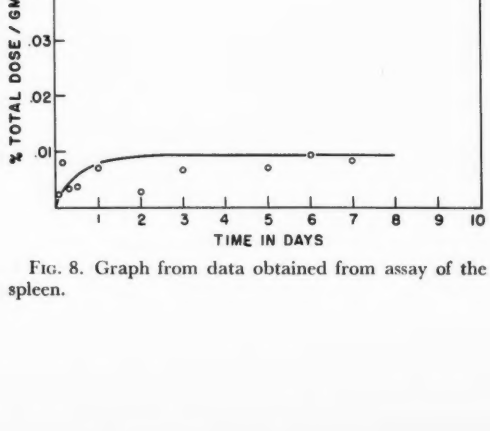

FIG. 8. Graph from data obtained from assay of the spleen.

The curves obtained from analysis of the right axillary (Fig. 4) and the right internal mammary nodes (Fig. 5) were similar. In each case the peak was flat, in contrast to those from the ipsilateral side. The peak concentration of 0.45 per cent specific concentration occurred at 72 hours, 24 hours later than on the opposite side. In addition, the amount of radiation delivered to these nodes was approximately 25 per cent of that delivered to the ipsilateral axillary and internal mammary nodes.

Careful examination of the curve from the analysis of the right breast (Fig. 6) revealed a lag of 2 to 4 hours during which time the colloid front was advancing toward the uninstilled breast. After the arrival of the colloid in the breast, the equilibrium concentration was reached rather quickly. The significance of the rise in the concentration following day 5 has not been determined. It seems unlikely that the rise in this portion of the curve represented further gold colloid transport.

The graphs from data obtained from assay of the liver, spleen, and kidneys differ from those described (Figs. 7, 8, and 9). The mode of transport in the case of the liver, spleen, and kidneys appeared to be hematogenous rather than by macrophage action. Hence,

FIG. 10. Normal rabbit breast. × 67.

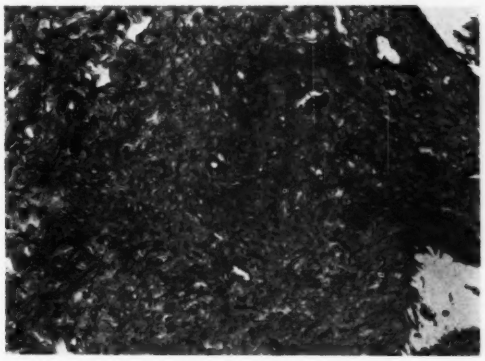

FIG. 12. Breast, 14 day interval. × 67.

the curve rose very abruptly and remained at a constant level of concentration. Presumably after the first 12 to 24 hours, no further gold colloid was filtered out by these organs. It appeared highly probable that a small fraction of the gold colloid was injected into the vascular system at the time of instillation of the breast. The concentration of gold colloid in these solid organs was, however, very low, less than 0.01 per cent specific concentration which was less than 1 per cent of that found in the breast and nodes.

Phase 3.2—Therapeutic doses of radioactive colloidal gold. To evaluate the local skin reaction, the left inferior thoracic mammary gland of 8 rabbits was injected with 11 cubic centimeter volumes of physiologic normal saline solution containing radioactive colloidal gold in concentrations of 2.0, 1.5, 1.0, and 0.5 millicuries per cubic centimeter. The animals were isolated and observed each day for evidence of local skin reactions. In the animals administered colloidal gold in concentrations of 0.5 and 1.0 millicurie per cubic centimeter, local induration was evident but no skin reaction. The rabbits receiving solution concentrations of 1.5 and 2.0 millicuries per cubic centimeter demonstrated local thickening of the tissue, local hyperthermia, and a superficial exudate which persisted for 3 months. The gross appearance of the breast epithelium with various concentrations of Au^{198} follows: with injections of 2.0 or 1.5 millicuries per gram of tissue, the third week exudate formation on the surface persisted at 3 months; with injections of 1.0 or 0.5 millicuries per gram of tissue, no skin reaction was present at 3 months.

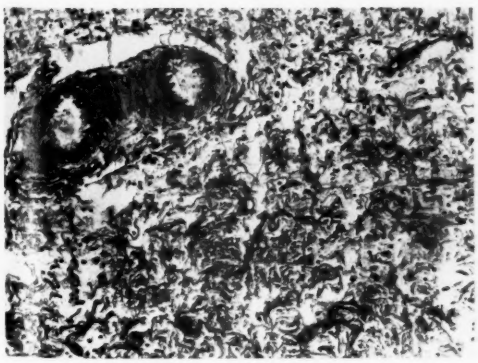

FIG. 11. Breast, 7 day interval. × 67.

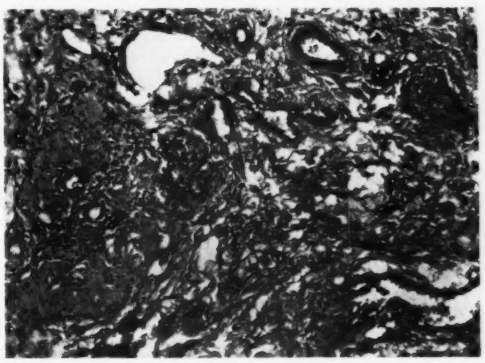

FIG. 13. Breast, 28 day interval. × 67.

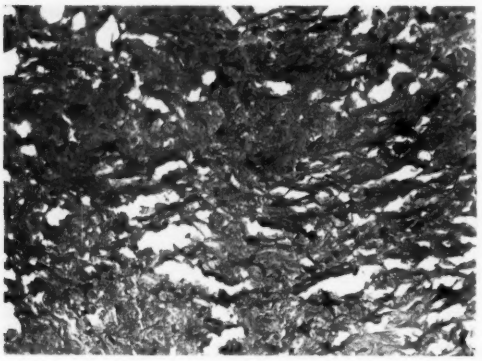

FIG. 14. Breast, 84 day interval. × 67.

The radiation effects of therapeutic doses of radioactive colloidal gold, 2 millicuries per gram of tissue, were evaluated by micropathologic studies of the site of injection, the regional lymphatics, and the liver, spleen, and kidneys. Twelve rabbits were injected and proportionately sacrificed at 7, 14, 28, and 84 day intervals. All rabbits survived the appointed time.

Micropathologic results. The following results were observed:

a. Site of injection

7 day interval (Figs. 10 and 11). The breast tissue showed macrophages containing particulate matter. The fibroblasts were large and hyperchromatic.

14 day interval (Fig. 12). The tissue appeared to be more cellular and the macrophages and fibroblasts were frequently vacuolated.

28 day interval (Fig. 13). The tissue showed increased hyalinization and the macrophages and fibroblasts continued to show vacuolation.

84 day interval (Fig. 14). The mammary gland has been replaced with scar tissue. Many of the phagocytes showed a bizarre, degenerative change, and others had died leaving clumps of particulate matter.

b. Regional lymph nodes

7 day interval (Figs. 15 and 16). Changes representative of regional lymph nodes as observed in the left axillary lymph nodes are demonstrated. Generalized hyperplasia of the follicular and interfollicular lymphoid tissue was visualized. The capsule and surrounding connective tissue were densely infiltrated with plasma cells. The reticuloendothelial cells were increased in number. The follicles showed reactive centers with macrophages containing large numbers of lymphocytic fragments. Inconspicuous phagocytosis of colloidal particles was evident in considerable concentration in the subcapsular and trabecular areas and present to a lesser degree in the medullary areas.

14 day interval (Figs. 17 and 18). The lymphocytes showed almost complete depletion from the intervals between the fibrous framework of the lymph gland. The sinuses were edematous and open. In the background was noted a predominence of reticuloendothelial cells along with smaller aggregates of lymphocytes and plasma cells. There was no evidence of phagocytosis. The vessel walls were edematous and thrombosed. Large extracellular aggregates of amorphous foreign material were present in the hilar and subcapsular areas.

28 day interval (Fig. 19). Reinvasion of the lymph gland by lymphocytes and reticuloendothelial cells had occurred. The subcapsular area showed foci of lymphocytes. The hilar area had somewhat re-

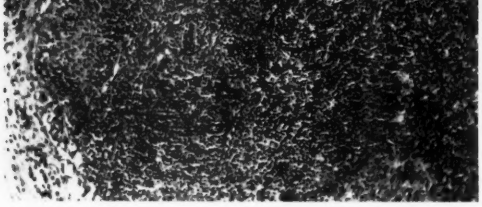

FIG. 15. Axillary nodes, 7 day interval. × 67. Low power view of hyperplasia of lymphocytes and reticulum cells in ipsilateral axillary lymph node 7 days after injection of Au^{198} into breast.

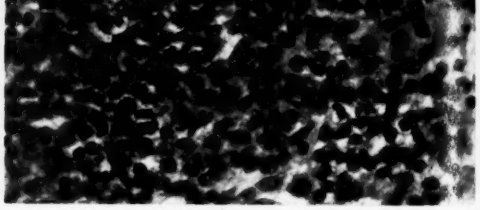

FIG. 16. Axillary node, 7 day interval. × 318. High power view of same lymphocytic and reticular hyperplasia that is demonstrated in the photomicrograph of Figure 15.

covered although the vessel walls demonstrated persistent lymphocytic infiltration and some evidence of cellular repair. Large aggregates of amorphous foreign material manifested a tendency to accumulate near the hilum.

84 day interval (Figs. 20 and 21). Considerable thickening and fibrosis of the capsule and trabeculi were evident. The sinusoids were densely infiltrated with lymphocytes and plasma cells. Germinal centers were present.

c. Liver, spleen, and kidney

Sections of the liver at 14 and 28 days showed areas of vacuolization (Figs. 22, 23, 24, and 25). Whether this change is secondary to nutrition or radiation has not been determined. The 84 day section resembled the section of the normal rabbit liver (Fig. 26). Additional studies need to be performed to evaluate properly the importance of this observation. No effects were noted in the kidney and spleen.

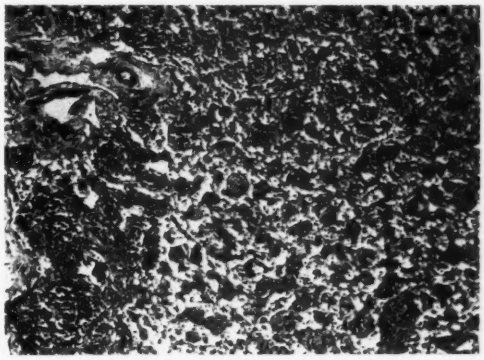

FIG. 17. Axillary node, 14 day interval. × 67. Low power view of ipsilateral axillary lymph node 2 weeks after injection of Au^{198} into breast. There is marked depletion of lymphocytic tissue.

EXPERIMENTAL ERRORS

The discussion of experimental errors in this study may be divided into three main categories: (1) statistical errors of radioactive assay, (2) systematic errors in specimen sampling, (3) systematic errors in the calculation of percentage of specific concentration due to animal response and variability.

The radioactive counting errors were relatively small. The aliquot activity varied from sample to sample with the left breast displaying the highest specific activity and the liver, spleen, and kidneys the lowest. The standard deviation thus varied from 1 to 3 per cent for these tissue aliquots. Breast and lymph tissue deviation was 1 per cent.

The mechanical problem of sampling the various tissues introduced somewhat larger errors. It was expected that, particularly in the excision of small specimens such as the lymph node, certain errors of weight would be difficult to avoid. This has been found to be the case and it is estimated that this factor introduces an error of about 5 to 15 per cent into the calculation of percentage of specific concentration.

Errors introduced into the sampling procedure through variation in rabbit size and

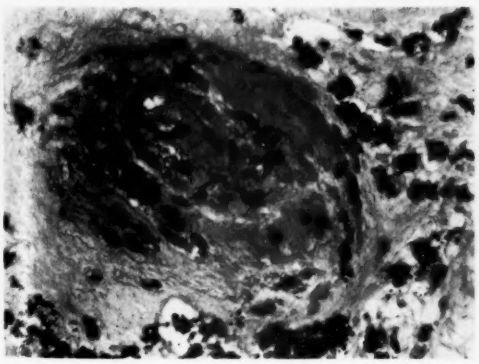

FIG. 18. Axillary node, 14 day interval. × 318. High power view of hilar area of same node depicted in Figure 17. Fibrinoid degeneration and thrombosis of vessel. Reticuloendothelial cells contain colloidal particles.

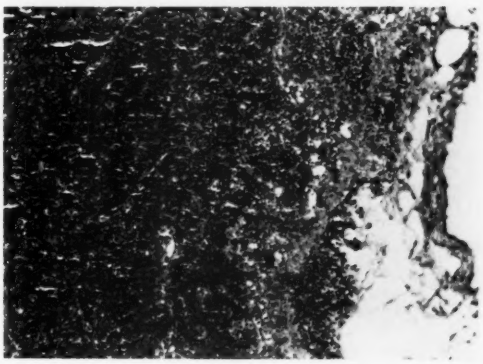

FIG. 19. Axillary node, 28 day interval. × 67. Low power view of entire thickness of ipsilateral axillary lymph node 28 days after injection of Au^{198} into breast. There is some recovery of lymphocytic tissue.

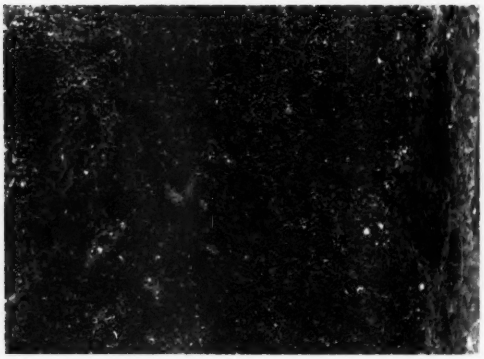

FIG. 20. Axillary node, 84 day interval. × 67. Low power view of only a small portion of the markedly hyperplastic ipsilateral axillary lymph node 84 days after injection of Au^{198} into breast.

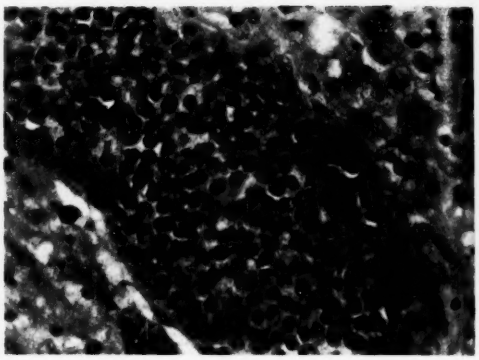

FIG. 21. Axillary node, 84 day interval. × 318. High power view of hyperplastic medullary area of same node as Figure 20. Note that hyperplasia in this area is due to an unusual increase in plasma cells.

differences in gland structure are recognized to have a large effect upon the final assay of tissue concentration. To obviate this factor the animals were chosen to have about uniform characteristics of weight, age, and development.

RADIOACTIVE COLLOIDAL GOLD AS A TRACING AGENT

In a study of this type, it is rather easy to overlook the usefulness of this particulate sized colloid in tracing lymph transport since the study was primarily directed toward the fixing of the colloid, and thus only indirectly concerned with the movement of the material.

The stable inert colloid can be provided with a specific activity of 4 to 6 millicuries per milligram of metal. This specific activity can be changed by radioactive decay or straightforward dilution with the stable colloid. In addition, the particle size may be varied somewhat and the colloid may be combined with numerous diluents and agents such as saline and pectin.

The variables above coupled with the sensitivity of the tracer method provide good potential for use of the gold particles in a spectrum of lymph chain studies. For tracer levels dilutions of a million are easily assayed with a minimum gold mass of about 10 micrograms used for the process.

This colloid then can provide a mechanism for: (1) the determination of lymph transport of inert particulate material of variable size; (2), a determination of the degree of "loading" of the lymph system, i.e. the total number of particles which the system can carry before saturation of the pathways; (3) the determination of aberrant lymph chain pathways by using tracer amounts; (4) the study of the valve system of the lymph chain and its malfunction under the stress of pressure and inflammation.

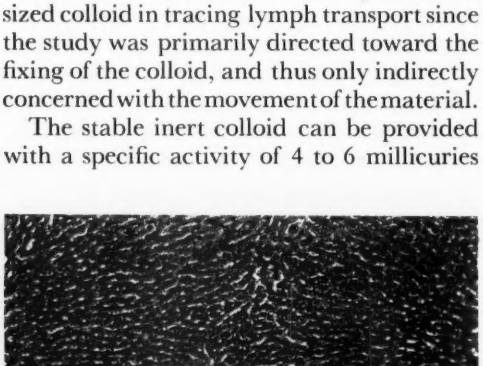

FIG. 22. Normal rabbit liver. × 67.

DISCUSSION

The data from the tracer studies herein reported showed that in the rabbit, lymphatic drainage from the left inferior thoracic mammary gland occurred in the following

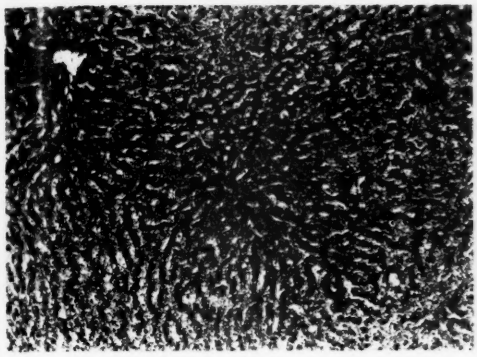

FIG. 23. Liver, 7 day interval. × 67.

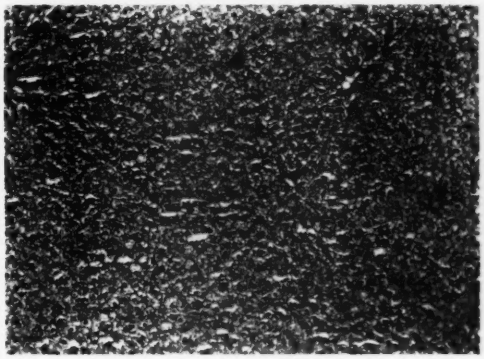

FIG. 24. Liver, 14 day interval. × 67.

order: left internal mammary lymph glands, left axillary lymph glands, right corresponding breast, right internal mammary lymph glands, and right axillary lymph glands, respectively. On a quantitative basis, the percentage of colloidal gold which traversed the midline to gain access to those contralateral organs averaged about 20 per cent of that localizing in the ipsilateral glands. Likewise, hematogenous spread occurred promptly following the injection, but the order of magnitude was about 100 times less than the amount of the colloid deposited in the lymph glands.

The uptake of radioactive colloidal gold in the regional lymph nodes has been attested by several workers. Sherman and his associates (18–20) showed experimentally that radioactive colloidal gold injected into paracervical tissue entered the regional lymphatic system and reached primary and secondary lymph nodes. Definite tissue tolerance and therapeutic levels for normal structures were stated to range within 1.25 to 1.75 millicuries per gram of parametrial tissue. Their work further revealed the mechanism whereby radioactive colloidal gold suspension, when injected interstitially in the breasts and parametria of dogs, was collected by phagocytes and transported through lymphatic pathways to regional lymph nodes where the colloid particles were trapped and concentrated. The uptake of subcutaneous and intramuscular radioactive colloidal gold by lymph nodes in dogs has been investigated by Jackson and co-workers. Berg (4, 5) showed that the concentration of colloidal gold in regional lymph nodes was contingent upon the size of the initial dose.

Hahn demonstrated that the silver-coated form of the gold colloid was more readily picked up by pulmonary lymphatics than was the uncoated gold. Wheeler and coworkers found good localization of radiation and extensive necrosis in regional lymph nodes in the lung of the dog after submucosal injection of radioactive gold in the bronchus. Solutions sprayed into the lung tended to remain localized and were much less effective in reaching the lymph nodes.

The clinical application of radioactive colloidal gold has many ramifications, and its use has met with varied success. Reports,

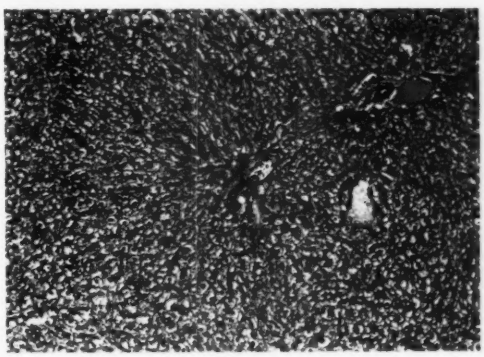

FIG. 25. Liver, 28 day interval. × 67.

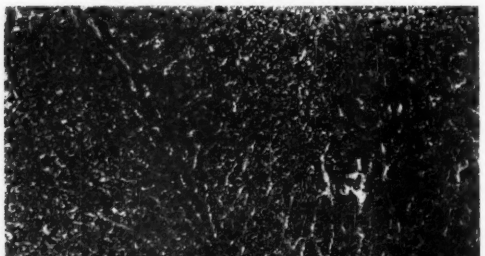

FIG. 26. Liver, 84 day interval. × 67.

such as those by Cron and Keettel and their associates, attesting to its effectiveness in the treatment of effusions secondary to malignancy have become quite numerous since introduced by Müller (15) in 1949.

Müller and Rossier (16) described a method of treating a segment of lung by injecting radioactive colloidal gold through a catheter previously threaded into the pulmonary artery by way of the heart. Numerous investigators have shown that a considerable amount of radiation to the lung parenchyma and regional lymph nodes in bronchiogenic cancer can be achieved by intratrachial and intrabronchial administration. However, Meneely and co-workers expressed little encouragement for the use of transbronchial instillation of radioactive colloidal gold in the treatment of cancer of the lung. This attitude is perhaps in keeping with the experimental work of Wheeler mentioned before.

Flocks and his associates (7, 8) stated that 90 per cent of the radioactive colloidal gold remained at the site of injection when injected intraprostatically, but that it was nontoxic. They also stated that 1 millicurie of radioactive colloidal gold per cubic centimeter of tissue represented approximately 65,000 roentgens equivalent physical of beta dosage.

The potentiality of treating the regional lymphatics with radioactive colloidal gold in carcinoma of the cervix was first investigated by Sherman and associates (18, 20). The recent report of Allen and co-workers (2), using colloidal gold in the treatment of carcinoma of the cervix was encouraging.

The experimental application of radioactive isotopes to breast cancer was done by Allen and his associates (1). They reported the regressive effect of insoluble radiophosphorus (chromium phosphate) when applied interstitially in the treatment of adenocarcinoma of the mammary gland in mice. Little of the radioactive material was carried to the regional lymph nodes. The use of radioactive colloidal gold for the detection of lymph nodes in radical excision of the breast has been used by Hultborn and coworkers (10, 11).

Berg and Christophersen (3) reported that differing amounts of radioactive gold injected into the breast of the dog resulted in varying concentrations of activity in the regional nodes. In addition, the distribution of the gold was random and casual. Seaman and Powers after injecting tracer amounts of radioactive gold into human breasts prior to radical mastectomy found sporatic and haphazard distribution of the gold in the regional lymph nodes.

The regional lymph nodes in all of the rabbits studied in this investigation showed a high percentage specific concentration of radioactive gold. Gold was present in all the regional lymph nodes, both ipsilateral and contralateral. The concentration was particularly high in the nodes from the ipsilateral side. In order to accomplish homogeneous distribution in the regional nodes the breast must be homogeneously infiltrated with volumes of solution equal to 1 cubic centimeter per gram of tissue.

The investigation showed that the maximum radiation was delivered to the regional lymph nodes. The concentration of radioactive gold in the nodes on the basis of calculated dose indicated a new order of magnitude in terms of radiation dosage. Examination of the sections of lymph nodes revealed micropathologic changes which were more pronounced than were produced by external

radiation. The rate of migration was sufficiently rapid to minimize severe local reaction at the site of injection.

The therapeutic use of radioactive gold would seem to be quite safe. A minimum amount of radiation was delivered to the spleen, liver, and kidney. Patients under therapy and laboratory animals have shown few untoward effects.

The greatest hazard to personnel in the handling of radioactive gold occurs at the time of injection. Since radioactive gold is an electronegative colloid, it binds very firmly to tissues and metal surfaces. Hence, at the time of injection, all personnel must be gowned, gloved, the floor covered with disposable paper, and the amount of contamination monitored by a physicist. Lead shielded syringes and containers are required for the handling of the material. Relatives must be instructed to curtail the period of time spent in proximity to the patient for the first 11 days. Autopsy permits should be obtained in conjunction with advice of the physicist.

REFERENCES

1. ALLEN, H., HEMPELMANN, L. H., JR., and WOMACK, N. A. The effect of insoluble radiophosphorus (chromium phosphate) when applied interstitially in the treatment of adenocarcinoma of the mamma in mice. Cancer Res., 1945, 5: 239–246.
2. ALLEN, W. M., SHERMAN, A. I., and ARNESON, A. N. Carcinoma of the cervix: results obtained from the irradiation of the parametrium with radioactive colloidal gold. Am. J. Obst. Gyn., 1955, 68: 1433–1446.
3. BERG, H. F., and CHRISTOPHERSEN, W. M. An experimental study of intramammary injection of Au^{198}. Ann. Surg., 1956, 143: 92–97.
4. BERG, H. F., CHRISTOPHERSEN, W. M., ISAACS, A. M., and BRYANT, J. R. Localization of radioactivity in regional lymph nodes. Arch. Surg., 1953, 67: 228–243.
5. BERG, H. F., ISAACS, A. M., and CHRISTOPHERSEN, W. M. Localization of radioactivity in the urinary bladder and the regional lymph nodes. J. Urol., Balt., 1954, 72: 382–388.
6. CRON, R. S., COWAN, I. I., GORTHEY, R. L., and KARIORIS, F. G. Surgery and radioactive gold treatment for carcinoma of the ovary. Am. J. Obst. Gyn., 1955, 70: 910–917.
7. FLOCKS, R. H., KERR, H. D., ELKINS, H. B., and CULP, D. The treatment of carcinoma of the prostate by interstitial radiation with radio-active gold (Au^{198}): preliminary report. J. Urol., Balt., 1952, 68: 510–522.
8. Idem. The treatment of carcinoma of the prostate by interstitial radiation with radioactive gold (Au^{198}): follow-up report. J. Urol., Balt., 1954, 71: 628–633.
9. HAHN, P. F., and CAROTHERS, E. L. Lymphatic drainage following intrabronchial instillation of silver-coated radioactive gold colloids in therapeutic quantities. J. Thorac. Surg., 1953, 25: 265–279.
10. HULTBORN, K. A., and JONSSON, L. I. The use of colloidal Au^{198} for the detection of lymph nodes in radical excision of the breast. Acta radiol., Stockh., 1955, 43: 132–138.
11. HULTBORN, K. A., LARSSON, L. G., and RAGNHULT, I. The lymph drainage from the breast to the axillary and parasternal lymph nodes, studied with the aid of colloidal Au^{198}. Acta radiol., Stockh., 1955, 43: 52–64.
12. JACKSON, A. H., STAGGERS, F. E., and HAHN, P. F. The uptake of subcutaneous and intramuscular silver-coated radioactive gold colloids by lymph nodes in dogs. J. Laborat. Clin. M., 1953, 42: 739–745.
13. KEETTEL, W. C., and ELKINS, H. B. Experience with radioactive colloidal gold in the treatment of ovarian carcinoma. Am. J. Obst. Gyn., 1956, 71: 553–568.
14. MENEELY, G. R., AUERBACK, S. H., WOODCOCK, C. C., KORY, R. C., and HAHN, P. F. Transbronchial installation of radioactive gold colloid in the lung of the dog; distribution studies, survival and pathology. Am. J. M. Sc., 1953, 225: 172–177.
15. MÜLLER, J. H. Zuer medizinisch-therapeutischen Verwendung der kuenstlichen Radioktivitat. Bull. Schweiz. Akad. med. Wiss., 1949, 5: 484–510.
16. MÜLLER, J. H., and ROSSIER, P. H. New method for treatment of cancer of lungs by means of artificial radioactivity. Acta. radiol., Stockh., 1951, 35: 449–467.
17. SEAMAN, W. B., and POWERS, W. E. Studies on the distribution of radioactive colloidal in regional lymph nodes containing cancer. Cancer, 1955, 8: 1044–1046.
18. SHERMAN, A. I., BONEBRAKE, M., and ALLEN, W. M. The application of radioactive colloidal gold in the treatment of pelvic cancer. Am. J. Roentg., 1951, 66: 624–638.
19. SHERMAN, A. I., NOLAN, J. F., and ALLEN, W. M. The experimental application of radioactive colloidal gold in the treatment of pelvic cancer. Am. J. Roentg., 1950, 64: 75–85.
20. SHERMAN, A. I., and TER-POGORRIAN, M. Lymph node concentration of radioactive colloidal gold following interstitial injection. Cancer, 1953, 6: 1238–1240.
21. WHEELER, H. B., JAQUES, W. E., ALLEN, M. B., SOLTES, M., O'CONOR, V. J., JR., and BLACK, H. Mediastinal lymph node irradiation with the use of radioactive gold. Surg. Gyn. Obst., 1956, 102: 166–176.

A CLINICAL AND PATHOLOGIC STUDY OF ENDOMETRIOSIS OF THE LUNG

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THE TERM "vicarious menstruation" has been used repeatedly in the medical literature, generally in reference to clinical observations of recurring hemorrhages from the nasal or tracheobronchial passages, and occurring in female patients with a chronology suggestive of a real or apparent correlation with the menstrual cycle. It was only natural that as soon as the concept of endometriosis became familiar to the medical profession, these vicarious menstruations should have been ascribed to the presence of ectopic endometrial tissue in the respiratory tract. However, while observations of extragenital endometriosis in general are not rare, documented acceptable instances of pulmonary endometriosis have not yet been reported to our knowledge.

The case to be reported here is therefore probably unique. It is noteworthy that the correct diagnosis was considered on clinical grounds, but proof was lacking until pregnancy intervened. In fact, it was the subsequent decidual reaction occurring in the ectopic endometrium which produced in the lung an obvious x-ray shadow, while previous roentgenologic studies had been negative.

CASE REPORT

Mrs. S. Y. (Presb. Hosp. Unit No. 246733), a 34 year old Japanese medical technician in a tuberculosis sanatorium, was in good health until October 1952 when she awakened one morning with a tickling sensation in her throat and coughed up a small amount of thin, bright red blood. In November 1952 she noticed a slight hoarseness. Three more episodes of hemoptysis, each consisting of a tablespoon of bright red blood, occurred in December 1952, at which time she consulted her physician.

There was no history of weight loss, fever, night sweats, dyspnea, or chest pain. Roentgenograms of the chest including tomograms revealed a suspicious infiltration in the left apical region. An erythrocyte sedimentation rate of 34 millimeters per hour was reported and she was admitted to the hospital for investigation.

Her past health consisted of a transient "pleurisy" in 1943 at which time she became tuberculin positive. Her first child was born by cesarean section in February 1952, because of cephalopelvic disproportion. Because of progressive menorrhagia, a curettage was performed in May 1952 and showed "endometrial hyperplasia."

The suspected clinical diagnosis of tuberculosis was never confirmed. Histoplasmin and coccidioidin skin tests were negative. The hemogram was normal and the erythrocyte sedimentation rate of 15 millimeters per hour. Repeat x-ray films including posteroanterior, right and left oblique apicograms, and right and left lateral films failed to reveal any abnormality. Bronchoscopic examination revealed several small, submucosal hemorrhages in the right stem and upper lobe bronchi.

A diagnosis of hemorrhagic telangiectasia of the bronchial tree was considered and she was given 0.1 milligram of estinyl for 10 days preceding her menses, according to a plan of treatment suggested by Koch and his associates. This therapeutic trial was followed by a larger hemoptysis, protracted menses, and a feeling of depression. The treatment was therefore discontinued.

From January to September 1953 she continued to have occasional hemoptyses usually associated with her menses. In September 1953 she was seen in consultation with a gynecologist who found nothing remarkable on physical examination. A diagnosis of vicarious menstruation possibly due to pulmonary endometriosis was apparently suggested at this time. Accordingly, 25 milligrams daily of methyl testosterone for 10 days preceding each menstrual period was prescribed for 2 menstrual cycles. In addition, premenstrual and postmenstrual roentgenograms of the

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chest were ordered for comparison. These failed to reveal any detectable changes.

While under androgen therapy, 1 episode of hemoptysis occurred in September 1953 but none in October 1953, after which hormonal therapy was discontinued. Except for a minor episode in January 1954, no further hemoptysis occurred. Monthly roentgenograms of the chest continued to show no obvious changes in the pulmonary shadows.

She remained well until August 1955 when she began to have nausea and vomiting, crampy lower abdominal pain, right shoulder pain, and a brownish vaginal discharge. The last menstrual period had occurred on July 16, 1955. An Aschheim-Zondek test on September 20 was positive.

On September 21 she was admitted to the hospital for observation because of severe crampy left lower quadrant pain and right subscapular and shoulder pains, which were aggravated by motion and deep respiration. These symptoms had been present intermittently for 3 weeks and constantly present for 5 days. Dark brown vaginal staining continued to be intermittently present. Examination revealed both direct and rebound tenderness in the left lower abdominal quadrant, but no masses were palpable. The uterus was enlarged to the size of 3 months' gestation, was soft, and slightly tender. The cervix was closed. There were no adnexal masses. Laboratory studies were unremarkable. A diagnosis of threatened abortion of an intrauterine gestation was made and the patient was kept in bed on mild sedation. Investigation of the right subscapular pain by a posteroanterior and right lateral chest film on September 22 disclosed a round, 1.0 centimeter area of increased density in the right middle lobe and no other intrapulmonic or pleural abnormalities.

Laminogram studies revealed a solitary nodular density in the right middle lobe (Figs. 1 and 2) seen best at the 13 centimeter level. A careful comparison with previous films failed to reveal the presence of this lesion prior to this date. A coin lesion of the right middle lobe was diagnosed, the differential diagnosis resting between a tuberculoma or other form of granuloma, a primary or secondary neoplasm, or possibly an endometrioma, in view of the history of menstrual hemoptysis.

She remained in the hospital for 9 days during which time her symptoms generally improved. The vaginal bleeding, though occasionally bright red, was never more than a mere stain. She was allowed home to be readmitted on October 15 for an elective right thoracotomy. During the intervening period the right shoulder pain completely disappeared. The lower abdominal cramps and vaginal staining continued to be intermittent, but were never severe.

On October 18, 1955, a right thoracotomy was performed. A fairly well circumscribed round mass was found in the right middle lobe. A resection of the lateral segment of the right middle lobe was performed (R. W.), and the specimen was immediately examined pathologically, with the intent to rule out a possible malignancy and therefore the necessity of a more radical operation.

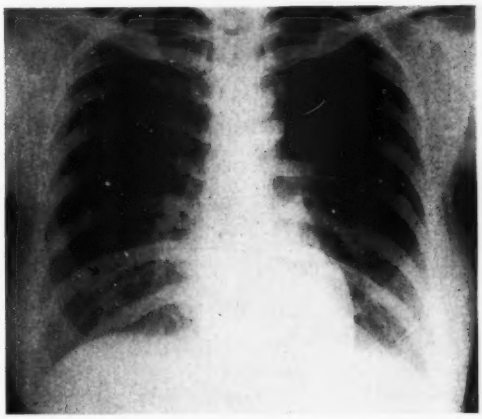

FIG. 1. X-ray film of the chest taken on September 22, 1955. Note small peripheral round shadow in the lower right lung field (arrow).

Gross description. On sectioning the resected specimen it was found to contain a round well circumscribed homogeneous pale tan somewhat translucent mass which bulged from the cut surface and measured 18 millimeters in greatest diameter (Fig. 3). A frozen section made by one of us (F. S.) showed histologic findings consistent with decidual tissue. The diagnosis of endometriosis of the lung with decidual reaction was suggested in a tentative way since none of us had had any previous experience with a similar case. The lesion was diagnosed as benign, and the chest was closed. The postoperative course was uneventful.

Microscopic description. The tissue was fixed in Bouin solution and in 10 per cent formalin and embedded in

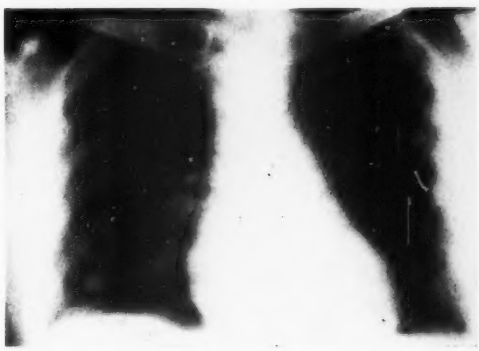

FIG. 2. Laminogram taken at the same date as Figure 1. The coin lesion is clearly seen in the lower right lung field.

FIG. 3. Photograph of the fresh specimen removed at operation on October 18, 1955.

paraffin. Sections were stained with hematoxylin and eosin, Masson's trichrome, periodic acid Schiff, Laidlaw silver stain for reticulin, mucicarmine, and with the Prussian blue reaction for iron pigment.

These sections showed that the grossly described round mass consisted of a mosaic of large acidophilic cells associated with scattered tortuous glandular lumens (Figs. 6 and 7). This tissue had partially replaced the parenchyma of the lung, and was not well demarcated from it. Here and there, the mosaic of large polygonal cells could be seen associated with the basal membrane of bronchioles, and in one place a polypoid portion of this tissue could be seen to bulge through the wall of a bronchus, projecting into its lumen (Figs. 4 and 5). It must have been from one such area that the recurrent hemorrhages into the bronchial tree had taken place. The polygonal cells mentioned had vesicular nuclei varying slightly in size, and abundant pale eosinophilic cytoplasm. Silver stains showed that these cells were wrapped individually in a fine reticulin fibrillar network (Fig. 6). Similarly, Masson's trichrome demonstrated intercellular collagen fibers. These fibers stained in brilliant red with the Schiff stain. The glands varied in caliber, and were lined by low and high columnar nonciliated and nonsecreting cells, which bore no resemblance to those lining the adjacent small bronchi. Numerous thin-walled blood vessels of sinusoidal type were present in the tissue. Mitoses were not seen in either the stromal or glandular elements. Signs of old hemorrhage were not seen in the tumor itself, but deposits of hemosiderin pigment were observed in the adjacent lung tissue. This tissue then had all the morphologic features of endometrium which had undergone decidual transformation.

FIG. 4. Low power photomicrograph of the lesion. Note a polypoid mass of decidual tissue projecting in the lumen of the bronchus. In the upper right sector are 2 dilated endometrial glands. Hematoxylin and eosin.

The final diagnosis was "endometriosis of the lung, with decidual reaction, probably following hematogenous transportation."

On April 10, 1956, an elective secondary low flap cesarean section was performed (H. T.). There was no obvious evidence of pelvic or abdominal endometriosis. The patient has had 2 normal menstrual periods since delivery, and to this date no further episode of hemoptysis has occurred.

COMMENTS AND DISCUSSION

In this exceptional case the theory of hematogenous "metastasis" seems to explain best the sequence of events, since the first hemoptysis occurred in the fall of 1952, following 2 surgical procedures on the uterus (see clinical history). It is postulated that at the time of one of these operations a fragment of viable endometrium entered a uterine vein, and from there reached the lung where it found conditions favorable for its survival. From there on, this small island of ectopic endometrium responded to the stimulation of the ovarian hormones, much as the lining of the uterine cavity, or as the common foci of endometriosis.

It is well to keep in mind, however, that while the possibility of this sequence of events has been well demonstrated in experimental animals by Hobbs and Bortnick, for some unknown reason it seems to represent a highly improbable and quite exceptional occurrence in human pathology. In fact, as we have already stated, this case is apparently unique in the available literature. In 1912 Hart described an autopsy finding of multiple pulmonary lesions which he interpreted as adenomyosis of uterine origin. After studying his report and illustrations, we believe that the endometrial nature of that lesion is not proved satisfactorily, and

that the condition was probably one of multiple hemartomas, somewhat similar to a case observed recently by one of us (R. L.).

Hobbs and Bortnick described 3 cases in which there were hemoptyses associated with the menses. In 1 of these patients the symptoms ceased following x-ray castration. The outcome of the disease in the other 2 patients was not stated. While no doubt the clinical symptoms were suggestive of pulmonary endometriosis, there is no record of a pathologic documentation for any of them.

More recently Park described the microscopic finding of viable decidual tissue in the lung of a young woman who died 4 hours after delivery. This was a chance finding in a section taken at random. We have seen the sections of this interesting case and agree with the interpretation. No endometrial glands were found, but only a small number of well preserved decidual cells. These had apparently reached the lung some time prior to death, since they seemed to be lodged in the stroma, and with appropriate stains reticulin fibers could be seen to extend from the pulmonary tissue into the small decidual island. This case is apparently the only other existing report in which nontrophoblastic and nonneoplastic tissue of endometrial origin was described as having been transported to the lung and become implanted there. As pointed out before, however, here only a small cluster of decidual cells without glandular structures was found.

Decidual tissue in the lung was also observed by Hartz in a pregnant woman who died of heart failure. It is probable that this was a recent embolus rather than an established implant.

Recently we had the opportunity to study sections from a case somewhat similar to that published by Hartz. The material came from an autopsy performed by Gabriel Godman on a woman who died during delivery. Here, there were multiple small clusters of decidual cells apparently embolizing the capillaries of the interalveolar septa (Fig. 8).

It is probable that small emboli of decidua, with or without endometrial glands,

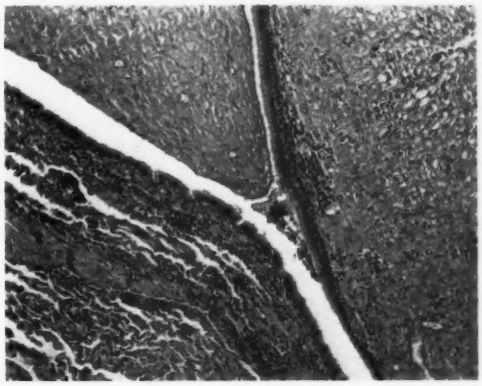

FIG. 5. Higher power photomicrograph of the same field, showing the columnar ciliated cells of the bronchial mucosa covering the mosaic of decidual cells at right. The polypoid projection is covered by unidentifiable flattened cells. Hematoxylin and eosin.

reach the lung at the time of delivery or during surgical procedures on the pregnant uterus, with a certain frequency. Apparently however, only exceptionally are these emboli viable, or do they find in the lung the environment favorable to their implantation and survival.

There are in the literature 2 other well documented cases of endometriosis in the thoracic cavity. Both of them involved the pleura and not the lung. One has been de-

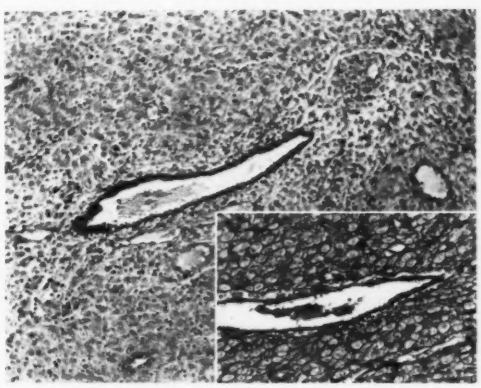

FIG. 6. Photomicrograph of the decidual tissue, with 1 slightly dilated gland lined by nonciliated columnar cells. Hematoxylin and eosin. Insert at lower right shows a similar area, stained for reticulin fibers with Laidlaw's silver method.

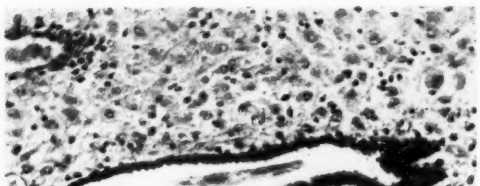

FIG. 7. Higher power photomicrograph of another area, showing an endometrial gland surrounded by decidual cells. Hematoxylin and eosin.

scribed, in 2 separate articles, by Nicholson and by Barnes. The patient, a 25 year old woman, had recurrent hemothorax and at thoracotomy the pleural surface was found covered with thick yellowish tissue which histologically included typical endometrial tissue. To explain the pathogenesis of this lesion the authors accept the theory of endometrial metaplasia of the mesothelial lining of the pleura, which has the same coelomic origin as the peritoneum.

Another acceptable case of pleural endometriosis is the second case in the article by Büngeler and his associate. A 42 year old woman who died of "chronic pneumonia" had both pleural cavities obliterated by adhesions. In the upper part of the right pleural cavity were 3 small nodular masses bearing the histologic features of endometrial glands and stroma with intervening fibrosis. Here again the pathogenesis of the lesions was ascribed to "coelomic metaplasia."

A case described by Brews of endometriosis of the diaphragmatic pleura should also be mentioned at this point. The woman, 39 years old, had ascites and pleural effusion. She was found to have diffuse peritoneal endometriosis, including the right diaphragm with involvement of the right diaphragmatic pleura. The condition was arrested by x-ray castration.

We believe that this is not the place for a detailed discussion of the several theories which have attempted to explain the pathogenesis of endometriosis. For this, the reader is referred to the already existing excellent reviews on this subject. Suffice it to say that probably not any one of these theories can account satisfactorily for all the cases in which ectopic endometrium-like tissue has been observed. No doubt the reported instances of extragenital endometriosis are those which have challenged most the imagination of the medical writers. The sites where proved cases of extragenital endometriosis have occurred, according to the available medical literature, include: perineum; urinary bladder; ureter; wall of small and large intestine; appendix; umbilicus; rectovaginal septum; laparotomy scars; pelvic, iliac, mesenteric, inguinal lymph nodes; kidney (1 or 2 cases known); upper extremity (1 case known); lower extremity (2 cases known); pleura (3 cases known); diaphragm (1 case known); lung (Presbyterian Hospital case).[1] Table I shows the distribution and frequency with which this condi-

[1]The case published by Park of small microscopic islands of decidual cells alone, without endometrial glands, is not included in this group since it did not have the complete structure of normal endometrium. Hartz' case was probably a recent embolus of decidual cells similar to the unpublished case of Godman.

FIG. 8. Photomicrograph of a small embolus of decidual cells found at autopsy in the lung of a young woman who died during delivery. There were many similar emboli in the capillaries of the interalveolar septa. Hematoxylin and eosin. (Courtesy of Dr. Gabriel Godman).

tion has been seen in the Columbia-Presbyterian Medical Center, according to the records of the Laboratory of Surgical Pathology.

Limiting our comments to the theories applicable to the cases of extragenital endometriosis, it would seem that for the instances in which endometrium-like tissue is observed in the peritoneal region (peritoneal lining and underlying or subcoelomic mesenchyme including intestinal wall, and perhaps also kidney), one can consider as most satisfactory the "coelomic metaplasia" concept of Ivanoff, Meyer, and Novak. This is the more attractive in that it seems to be supported by the not infrequent observations of decidual reactions in pregnancy, in focal areas of the peritoneal cavity (ex.: appendiceal serosa) in the absence of true glandular endometriosis. As a general proposition, it seems that endometriosis can occur in any location related embryologically to the coelomic lining, the "subcoelomic mesenchyme," or their derivatives. However, it must be acknowledged that Sampson's theory of regurgitation and implantation can be used to explain the pathogenesis of some cases of abdominal endometriosis. In fact, besides some recent experimental work by Scott and TeLinde on the viability of regurgitated endometrium, the well known occurrence of endometriosis in laparotomy scars following surgery of the uterus demonstrates the possibility of implantation, growth, and function of minute fragments of human endometrium.

Endometriosis of mesenteric, retroperitoneal, and inguinal lymph nodes can also conceivably be explained by the theories of "coelomic metaplasia" or coelomic rests. However, we see no reason to rule out the possibility of "benign lymphatic metastases" as suggested originally by Sampson, and recently by Javert.

As for the much rarer occurrence of extraperitoneal endometriosis, it seems proper to point out that while the reported cases of pleural involvement can still be made to fit into the "coelomic metaplasia" theory, we find it hard to adapt this theory to the cases of endometriosis of the upper and lower extremities, as suggested by Gruenwald. We believe that in these instances, as well as in the case reported herein, the most logical explanation is that of a "benign hematogenous metastasis" followed by implantation and growth of the endometrial emboli.

TABLE I.—CASES OF EXTRAGENITAL ENDOMETRIOSIS IN PRESBYTERIAN HOSPITAL (SURGICAL PATHOLOGY)

	No. of cases
Large intestine (exclusive of rectum)	14
Rectum	8
Appendix	8
Small intestine	2
Peritoneum	13
Inguinal canal	5
Pelvic + inguinal lymph nodes	3
Laparotomy scars	8
Umbilicus	5
Rectovaginal septum	2
Lung	1
Total	69

CONCLUSIONS AND SUMMARY

A case of endometriosis of the lung is reported. It occurred in a 34 year old woman who for about 3 years had episodes of hemoptysis associated with the menses. These hemoptyses started following a cesarean section and an endometrial curettage for menorrhagia, and continued irregularly in spite of various hormonal treatments, until she again became pregnant. At about this time x-ray studies of the chest, which had previously been negative, showed a discrete coin lesion in the right middle lobe. Exploratory thoracotomy followed by segmental resection showed that the pulmonary mass consisted of endometrium with marked decidual reaction of the stroma. It was this decidual reaction which caused the previously present and functioning endometrial implant to enlarge and become detectable roentgenologically. The patient has since been delivered at term by cesarean section, and to the date of this writing further hemoptyses have not occurred.

After a very brief review of the most popular theories on the pathogenesis of extragenital endometriosis, it is suggested that

none of these theories explains satisfactorily all cases. For the case reported here, it is believed that hematogenous transportation and implantation of viable endometrium at the time of the previous uterine operations is the most plausible explanation.

REFERENCES

1. Barnes, J. Endometriosis of the pleura and ovaries. J. Obst. Gyn. Brit. Empire, 1953, 60: 823–824.
2. Brews, A. Endometriosis of the diaphragm and Meigs' syndrome. Proc. R. Soc. M., Lond., 1954, 47: 461.
3. Büngeler, W., and Fleury Silveira, D. Consideracoes sobre a patogenia das endometrioses. Arq. cirurg. clín., S. Paulo, 1939, 3: 169–187.
4. Godman, G. Personal communication.
5. Gruenwald, P. Origin of endometriosis from mesenchyme of celomic walls. Am. J. Obst. Gyn., 1942, 44: 470–474.
6. Hart, C. Histologisch benigne Metastasen Vom Bau eines Adenomyom 22 Jahre nach Extirpation eines Tumors der Genitalien. Frankf. Zschr. Path., 1912, 10: 78–90.
7. Hartz, P. H. Occurrence of decidua-like tissue in the lung; report of a case. Am. J. Clin. Path., 1956, 26: 48–51.
8. Hobbs, J. E., and Bortnick, A. R. Endometriosis of the lung; experimental and clinical study. Am. J. Obst. Gyn., 1940, 40: 832–843.
9. Ivanoff, N. S. Quoted by Javert (10).
10. Javert, C. T. Pathogenesis of endometriosis based on endometrial homeoplasia, direct extension, exfoliation and implantation, lymphatic and hematogenous metastasis. Cancer, 1949, 2: 399–410.
11. Idem. Observations on the pathology and spread of endometriosis based on the theory of benign metastasis. Am. J. Obst. Gyn., 1951, 62: 477–487.
12. Koch, H. J., Escher, G. C., and Lewis, J. S. Hormonal management of hereditary hemorrhagic telangiectasis. J. Am. M. Ass., 1952, 149: 1376–1380.
13. Meyer, R. Ueber entzundliche heterotope Epithelwucherungen im Weiblichen Genitalgebiete. Virchow's Arch., 1909, 195: 487–536.
14. Nicholson, H. Endometriosis of pleura. Thorax, 1951, 6: 75.
15. Novak, E. Gynecological and Obstetrical Pathology. 2nd ed. Philadelphia: W. B. Saunders Co., 1947.
16. Park, W. W. The occurrence of decidual tissue within the lung. Report of a case. J. Path. Bact., Lond., 1954, 47: 563–570.
17. Sampson, J. A. The life history of ovarian hematomas (hemorrhagic cysts) of endometrial (Mullerian) type. Am. J. Obst. Gyn., 1922, 4: 451–512.
18. Idem. Inguinal endometriosis (often reported as endometrial tissue in groin, adenomyoma in groin, and adenomyoma of round ligament). Am. J. Obst. Gyn., 1925, 10: 462–503.
19. Idem. Development of the implantation theory for origin of peritoneal endometriosis. Am. J. Obst. Gyn., 1940, 40: 549–557.
20. Scott, R. B., TeLinde, R. W., and Wharton, L. R. Further studies on experimental endometriosis. Am. J. Obst. Gyn., 1953, 66: 1082–1103.

BIOPSY OF THE BREAST FOLLOWED BY DELAYED RADICAL MASTECTOMY

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THE VALUE OF BIOPSY of an indeterminate lesion of the breast is well appreciated by those interested in this problem because fat necrosis, sclerosing adenosis, plasma cell mastitis, and, at times, "blue domed" cysts can be confused with cancer of the breast. Storrs has reported that of a series of lesions diagnosed clinically as malignant, only 70 per cent proved to be malignant on pathologic examination, whereas 13 per cent of the lesions diagnosed clinically as being benign were in actuality malignant.

Evolution of biopsy in general began when Virchow advocated it as a diagnostic aid in treatment. Impetus to the problem was augmented by Wilson's (25) description of his frozen section technique, Greenough's (7) grading of malignant lesions of the breast, Hellwig's general review of the scientific basis of biopsy in tumors, and Dockerty's recent discussion of the refinements of rapid frozen section technique for microscopic diagnosis of surgical specimens.

In the earlier writings the adverse effects of biopsy were emphasized although no substantiating proof was presented. Ewing and Adair (1, 2) expressed the opinion that biopsy opened lymphatics and that sponging and pressure disseminated the cells. Ewing stated that the hyperemia of the resulting inflammatory process might also stimulate tumor growth and even cause dislodgment of more tumor cells. Because of these factors, Adair (1) condemned incisional biopsy and even recommended changing gloves and instruments if the surgeon cut into the tumor. At this time, he advocated aspiration or punch biopsy but preferred total excision when it could be done initially. Harrington (10-12), Shallow and associates, and Haagensen and Stout have also strongly proposed that a wide wedge excision be done in order to lessen the possibility of metastasis if the lesion should prove to be malignant.

Today, it is presumed that malignant cells are almost constantly invading the vascular system in a number that far exceeds the number of instances of metastasis. It is believed that most of these cells perish within the vascular system. In the opinion of Engelbreth-Holm, rough palpation, especially massage, of a cancer of the breast increases the number of cells in the vascular tree far more than does biopsy itself and is, therefore, a much greater hazard as far as metastasis is concerned. The rate of local recurrence has ranged from 10 to 18 per cent regardless of whether or not a preliminary biopsy was done prior to radical mastectomy.

In this article we have not directed our interest toward the value of biopsy per se in cancer of the breast, but we have concerned ourselves primarily with those patients who had had some type of biopsy done before coming to the Mayo Clinic for definitive treatment. We hoped to determine what effect, if any, such delay might have upon the chance of survival of a given patient. We wish to make it clear at this point that we are talking of delay in terms of days and even months in having a radical mastectomy done and not in terms of a few minutes as is necessary for a frozen section diagnosis. In an earlier study, we had determined that 58.5 per cent of 650 surgically treated patients in 1947 and 1948 had had a biopsy while they were on the operating table pre-

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TABLE I.—DISTRIBUTION OF PATIENTS BY LOCATION OF LESION

Location in breast	*Patients*	*Per cent*
Upper outer	33	39.2
Lower outer	12	14.3
Upper inner	10	11.9
Lower inner	4	4.8
Central	3	3.6
3 o'clock	3	3.6
6 o'clock	4	4.8
9 o'clock	6	7.1
12 o'clock	9	10.7
Total	84*	100

*12 patients had lesions that were too extensive for definite localization as quadrant.

pared to undergo radical mastectomy if the diagnosis of malignancy were substantiated.

In the past, 7 to 11 per cent of patients undergoing the usual Halsted type of radical mastectomy have had some type of minor operative procedure performed prior to their coming to the clinic. Harrington (10,12) has said that this is one of the most important reasons for the unsatisfactory results in the surgical treatment of cancer of the breast and that these patients do less well than any group with such cancer except those who are pregnant or are lactating concurrently with the malignant process. Adair (2) has pointed out that for a group of 283 similar patients, the 5 year survival rate was only 20 per cent, whereas in 7,136 other patients without biopsy before they came to him, the over-all 5 year survival rate was 51 per cent.

In addition to a poorer prognosis, Harrington (12) has said that patients who have undergone a prior minor operative procedure have a higher incidence of axillary nodal metastasis by the time definitive radical mastectomy is accomplished—some 79 per cent as compared to 60.7 per cent for patients treated primarily.

To the contrary, Nohrman, Scheel, and Kaae were not able to demonstrate from their material either any increased incidence of metastasis or any progression from a Steinthal stage 1 to a stage 2 lesion in the interim between biopsy and radical mastectomy; however, Kaae had reported earlier that the incidence of stage 2 lesions multiplied with the increase of time between the first signs and operation. Survival rates for patients who had experienced an interim between biopsy and mastectomy were demonstrated to be equal to or better than those obtained after radical mastectomy without such an interim by Röden, Greenough, Siemens, Lee, Scheel, and Fries. They attributed some of this to the fact that the lesions subjected to biopsy had fewer characteristics of cancer and were in all probability earlier lesions in which one could naturally expect a better prognosis. The interval between biopsy and radical mastectomy, however, is not given by Greenough and Siemens. The definitive operation was done within 6 days to 4 weeks after biopsy by Röden, within 1 to 3 weeks by Lee on a very small group, and from less than 6 weeks to more than 16 weeks by Scheel. The group reported by Fries had an interval of 7 to 10 days between biopsy and radical mastectomy. Nohrman, from 91 cases with previous biopsy in a total group of 1,042, believed that a 3 day delay was critical and that longer delays did adversely affect the prognosis. Of 300 patients studied by Scheel, 112 had had previous biopsy, and it was concluded that a definitive operation could be done with absence of risk if performed within 1 to 33 days from the time of biopsy.

TABLE II.—DISTRIBUTION OF PATIENTS ACCORDING TO INTERVAL BETWEEN BIOPSY AND MASTECTOMY

Interval, mos.	*No.*	*Per cent*
0–½	33	34.4
½–1	40	41.6
1–6	13	13.5
6–12	6	6.3
12 or more	4	4.2
Total	96	100

In presenting the material to follow we appreciate the difficulty of comparing survival rates for a given group of patients in which mastectomy was done initially with those for another given group in which some type of minor operative procedure had been done some time prior to mastectomy.

PRESENT STUDY

We previously reported on a group of 650 patients who underwent mastectomy during 1947 and 1948 and who were studied in terms of survival as it was related to lesions

of the medial and lateral quadrants of the breast (17). During this same 2 year period, 104 patients (16.0 per cent) had undergone a preliminary biopsy before they came to the clinic. It was thought that under these similar, simultaneous circumstances we were justified in using the remainder group as a control with which we might compare survival rates for the group of 104 patients, referred to hereinafter as the biopsy group.

It was necessary to eliminate 8 of the 104 patients from this study. Four were eliminated because of unavailability of the original biopsy material obtained 10 years before from 2 patients and 9 and 8 years before respectively from the other 2 patients. The fifth patient for whom tissue was not available had undergone biopsy at a university center 17 days before, and no residual cancer was found in the specimen obtained by radical mastectomy. The sixth patient had an intraductal papilloma for which a simple mastectomy was done. The seventh patient had received x-ray therapy after the original biopsy at an unknown time in the past and had had biopsy of an axillary metastatic lesion before being advised to undergo radical mastectomy. The eighth patient noticed a local recurrent lesion 6 months after the initial biopsy and underwent partial simple mastectomy some 3 months before radical mastectomy.

Of the resulting 96 patients, 95 were women and 1 was a man. The average age was 48.2 years which is about 4 years younger than the average age of the larger series of Harrington. The youngest was 27 and the oldest 75 years of age. Two women had bilateral simultaneous cancer, and the breast of 1 woman contained 2 different areas which had previously been subjected to biopsy.

As to the type of definitive treatment, bilateral radical mastectomy was done in one instance, bilateral simple mastectomy was done in another instance, and local excision with axillary dissection as a palliative procedure was done in still another instance. One 75 year old patient with obesity, hypertension, and a history of recent pulmonary embolism underwent simple mastectomy alone. In the only man of the series, rebiopsy of the lesion for diagnosis alone was done because of the nature of the lesion and because 1 year had elapsed since the original biopsy. The other 91 patients underwent the usual Halsted type of radical mastectomy following variable intervals of delay.

TABLE III.—FIVE YEAR SURVIVAL RATES BY TYPE OF BIOPSY

	Patients		Lived 5 years or more after operation	
Type of biopsy	*Total*	*Traced*	*No.*	*Per cent**
Excisional	55	55	39	70.9
Incisional	41	40	19	47.5
Total	96	95	58	61.1

*Based on traced patients. Inquiry as of January 1, 1955.

Forty-eight patients had had biopsy of the right breast, 46 of the left, and 2 of both breasts. Three patients had had more than 1 biopsy, with the interval before mastectomy being 27 months and 3 months in the first patient, 5 weeks and 3 weeks in the second, and 29 weeks and 2 weeks in the third.

Twenty-nine patients had lesions of the medial half of the breast, 52 had lesions of the lateral half, and only 3 had lesions of the central or subareolar part. The distribution of the patients according to location of the lesion is given in Table I.

The interval between the initial procedure and definitive treatment ranged from 4 days to 2 years and 3 months. Thirty-three of the

TABLE IV.—DISTRIBUTION OF PATIENTS ACCORDING TO TYPE AND GRADE OF MALIGNANCY AND EVIDENCE OF METASTASIS TO THE AXILLARY NODES

Type	*Total patients*	*With metastasis*	*Without metastasis*
Adenocarcinoma			
Grade 1	6	—	6
2	13	3	10
3	24	14	10
4	40	23	17
Total	83	40	43
Comedocarcinoma			
Grade 1	—	—	—
2	3	—	3
3	5	1	4
4	2	—	2
Total	10	1	9
Paget's disease	3	2	1
Total	3	2	1
Grand total	96	43	53

TABLE V.—COMPARISON OF 5 YEAR SURVIVAL RATES BY LOCATION OF LESION IN BREAST IN BIOPSY GROUP AND CONTROL GROUP

	Biopsy group				*Control group*			
	Patients		*Lived 5 years or more after operation*		*Patients*		*Lived 5 years or more after operation*	
Location	*Total*	*Traced*	*No.*	*Per cent**	*Total*	*Traced*	*No.*	*Per cent**
Medial	29	29	15	51.7	97	97	59	60.8
Lateral	52	52	35	67.3	204	199	123	61.8
Central	3	3	2	66.7	31	30	16	53.3
Not localized	12	11	6	54.5	222	213	126	59.2
Total	96	95	58	61.1	554	539	324	60.1

*Based on traced patients. Inquiry as of January 1, 1955.

96 patients (34.4 per cent) delayed operation not more than 2 weeks, and 73 of the 96 patients (76.0 per cent) delayed operation not more than a month from the time of original biopsy (Table II). Only 4 patients delayed operation for more than a year.

Of 86 patients who underwent definitive surgery in 6 months or less after the biopsy, we were able to trace all, and surprisingly enough we found 56 alive 5 years later, giving a 5 year survival rate of 65.1 per cent for this group. Because of this unusual finding we believe that this problem deserves further study with a larger group. In the remaining 10 patients who waited more than 6 months, 9 were traced and only 2 lived 5 years or more, giving a 5 year survival rate of 22.2 per cent. Our over-all figures are given in a later section of this article.

Fifty-five of the biopsies had been excisional with no further cancer being found locally when tissue was examined thoroughly following mastectomy. Punch biopsy had been performed on 1 occasion, and a Vim-Silverman needle had been used only once—in the previously discussed elderly patient who underwent only a simple mastectomy. Of the remaining 39 biopsies, all were of the incisional type.

Wilson (24) earlier showed that patients who had excisional biopsy, before radical mastectomy, especially those who had no metastasis to the lymph nodes, had a better prognosis than those who did not have such a biopsy. In our series, the 55 patients who had undergone excisional biopsy had a 5 year survival rate of 70.9 per cent, whereas the 41 who had undergone incisional biopsy had a 5 year survival rate of 47.5 per cent (Table III).

Of 4 patients who were pregnant at the time the mass in the breast was discovered, only 1 aborted before term.

The distribution of the patients according to type and grade of lesion found on microscopic examination and according to evidence of metastasis to the axillary nodes is given in Table IV. It can be seen that 43 of the patients (44.8 per cent) had metastatic involvement of the axillary nodes at the time of their removal.

It is significant that only 4 of the patients had had a diagnosis of benign disease following the initial biopsy. The first had been told that the lesion was "not cancerous" 1 year before mastectomy. The second had been told 7 months before mastectomy that the lesion was a cyst. A third, who had undergone bilateral biopsies, had been told that both lesions were inflammatory 3 weeks before definitive treatment was undertaken on the first side for bilateral cancers. The second breast was removed 2 weeks after the first operation. The fourth patient had been

TABLE VI.—FIVE YEAR SURVIVAL RATES BY PRESENCE OR ABSENCE OF METASTASIS AND BY GRADE OF MALIGNANCY

	Patients		*Lived 5 years or more after operation*	
Group	*Total*	*Traced*	*No.*	*Per cent**
Without metastasis	53	52	39	75.0
With metastasis	43	43	19	44.2
Total	96	95	58	61.1
Grades 1 and 2	23	23	16	69.6
Grades 3 and 4	73	72	42	58.3
Total	96	95	58	61.1

*Based on traced patients. Inquiry as of January 1, 1955.

told 2 years before that the biopsy disclosed a benign condition. From this it seems probable that professional mismanagement or neglect had no significant part in the delay between initial biopsy and definitive treatment.

As seen in Table V, the over-all 5 year survival rate for the biopsy group is 61.1 per cent, and for the control it is 60.1 per cent. The 5 year survival rate for patients with lesions of the medial half of the breast is 51.7 per cent for the biopsy group and 60.8 per cent for the control group. For patients with lesions of the lateral half of the breast the 5 year survival rate is 67.3 per cent for the biopsy group and 61.8 per cent for the controls.

In the biopsy group the 5 year survival rate was 75.0 per cent for the group without axillary nodal metastasis and 44.2 per cent for the group with such metastasis (Table VI). For patients with grade 1 and grade 2 lesions the 5 year survival rate was 69.6 per cent and for those with grade 3 and grade 4 lesions it was 58.3 per cent.

COMMENT

We believe that our control group of 554 patients who underwent mastectomy is an ideal one with which to compare, from the standpoint of survival, the smaller group of 96 patients who had had biopsies at varying intervals before mastectomy. All definitive treatment was done in 1947 and 1948 by the same group of surgeons at the Mayo Clinic using their individual techniques and exercising their routine precautions.

While the over-all 5 year survival rates for the control group and the biopsy group are similar, being 60.1 per cent and 61.1 per cent respectively, a most striking difference is observed in the rates when the type of biopsy is considered; thus, the 5 year survival rate is 47.5 per cent when incisional biopsy is performed and 70.9 per cent when excisional biopsy is performed.

SUMMARY

Among 650 patients who underwent mastectomy at the Mayo Clinic during 1947 and 1948 there were 104 who had undergone biopsy at an appreciable interval prior to the mastectomy. Ninety-six of the 104 patients constituted the basis of this study and are referred to as the biopsy group. The remaining 554 patients constituted the control group.

There were 95 women and 1 man. The average age was 48.2 years, the range being from 27 to 75 years. Forty-eight of the lesions were in the right breast, 46 in the left breast, and 2 bilateral. In 1 breast there were 2 lesions. Twenty-nine of the lesions were localized to the medial half of the breast, 52 to the lateral half, and 3 to the central part. Twelve lesions were not specifically localized.

Thirty-nine of the biopsies were incisional, 1 was a punch biopsy, 1 was a Vim-Silverman needle biopsy, and the remaining 55 were excisional. Definitive surgical treatment was performed in 2 weeks or less after the initial biopsy in 34.4 per cent of cases, in 1 month or less in 76.0 per cent, and in 6 months or less in 89.6 per cent. Eighty-three of the patients had adenocarcinoma, 10 had comedocarcinoma, and 3 had Paget's disease. Axillary nodal metastasis had occurred in 44.8 per cent of the patients at the time of operation.

The over-all 5 year survival rate is 61.1 per cent for the biopsy group and 60.1 per cent for the control group. The 5 year survival rate is only 47.5 per cent for the patients who had incisional biopsy as compared to 70.9 per cent for those who had excisional biopsy.

A rather surprising finding was that 65.1 per cent of patients delaying definitive treatment up to 6 months were alive 5 or more years after mastectomy. A further investigation of this point is warranted on a larger group of cases.

The fact that the lesions in only 4 cases had been called benign when in reality they were malignant is a tribute to the increasing standards strived for by the profession.

REFERENCES

1. ADAIR, F. E. Clinical manifestations of early cancer of the breast. N. England J. M., 1933, 208: 1250–1255.

2. Idem. The role of surgery and irradiation in cancer of the breast. J. Am. M. Ass., 1943, 121: 553–559.
3. Dockerty, M. D. Rapid frozen sections technique of their preparation and staining. Surg. Gyn. Obst., 1953, 97: 113–120.
4. Engelbreth-Holm, J. Quoted by Kaae (14).
5. Ewing, James. Biopsy in mammary cancer. Illinois M. J., 1933, 63: 482–483.
6. Fries, Bengt. Results of treatment of cancer of the breast. Acta chir. scand., 1952, 103: 64–69.
7. Greenough, R. B. Varying degrees of malignancy in cancer of the breast. J. Cancer Res., 1925, 9: 453–463.
8. Idem. Early diagnosis of cancer of the breast. Ann. Surg., 1935, 102: 233–238.
9. Haagensen, C. D., and Stout, A. P. Carcinoma of the breast. Ann. Surg., 1951, 134: 151–172.
10. Harrington, S. W. Carcinoma of the breast; surgical treatment and results five, ten, and fifteen years after radical amputation. Surg. Gyn. Obst., 1933, 56: 438–441.
11. Idem. Unilateral cancer of the breast treated by surgical operation and radiation. Surg. Gyn. Obst., 1935, 60: 499–504.
12. Idem. Survival rates of radical mastectomy for unilateral and bilateral carcinoma of the breast. Surgery, 1946, 19: 154–166.
13. Hellwig, C. A. The scientific basis of biopsy in tumors. Arch. Path., Chic., 1932, 14: 517–554.
14. Kaae, Sigvard. Risk involved by biopsy in breast cancer. Acta. radiol., Stockh., 1952, 37: 469–478.
15. Lee, B. J. Quoted by Röden (18).
16. Nohrman, B. A. Carcinoma of the breast. Acta Radiol., 1949, suppl. 77, pp. 1–98.
17. Pierce, E. H., Kirklin, J. W., McDonald, J. R., and Gage, R. P. Carcinoma of the breast; lesions in the medial and lateral halves. In press.
18. Röden, Sture. On cancer of the breast, with special reference to the results of different methods of treatment. Acta Radiol., 1944, suppl. 57, pp. 1-50.
19. Scheel, Axel. Some prognostic factors, particularly biopsy, in carcinoma of the breast. Acta Radiol., 1953, 39: 249–254.
20. Shallow, T. A., Wagner, F. B., Jr., and Colcher, R. E. Adequate breast biopsy. Arch. Surg., 1953, 67: 526–536.
21. Siemens, W. Quoted by Röden (18).
22. Storrs, H. G. The role of excision biopsy in lesions of the breast. Am. Surgeon, 1952, 18: 1199–1206.
23. Virchow, R. Quoted by McGraw, A. B., and Hartman, F. W. Present status of the biopsy. J. Am. M. Ass., 1933, 101: 1205–1209.
24. Wilson, J. D. Incisional and excisional biopsy in mammary carcinoma. Thesis. Graduate School, University of Minnesota, 1952.
25. Wilson, L. B. A method for the rapid preparation of fresh tissues for the microscope. J. Am. M. Ass., 1905, 45: 1737.

SURGICAL MANAGEMENT OF CARCINOMA OF THE CERVIX

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THIS REPORT summarizes an experience of 10 years in the surgical management of cancer of the cervix. For 20 years prior to this 10 year period, there was increasing discouragement over the outcome of the patients treated for this disease and disappointment in the percentage of failures in cases which should have been salvaged. Though it seemed obvious that radiation was not the optimal approach to this disease, no other acceptable treatment existed.

Ten years ago, my first patient was subjected to the radical operation for the cure of carcinoma of the cervix. This woman was 6 weeks pregnant with unmistakable invasive carcinoma of the cervix. She is alive and well today and is an energetic, efficient teacher in our public school system. As initiated that morning, this surgical investigation is a procedure which I had often considered but had delayed, awaiting two events before subjecting myself to possibly serious criticism by fellow gynecologists and my patients to a possibly overwhelming mortality risk. These two events occurred. First, Meigs (3) published a report of 47 selected patients who had been operated upon without a fatality; and, secondly, the adjunct sciences had been sufficiently developed to permit logical consideration of such a procedure. The knowledge of electrolytic maintenance, the unrestricted use of blood transfusions, and the advent of the "wonder drugs" gave the stimulus, lacking during the previous 15 years, to attempt to evaluate such an approach to the treatment of a disease of such lethal potentialities.

MATERIAL AND THERAPEUTIC ATTACK

The material reported here represents the 89 patients operated on 5 years or more ago. Roughly, 75 per cent of these cases came from my private practice and the remaining 25 per cent from the gynecology service at the School of Medicine of the University of Oklahoma. Eighty-nine cases, of course, are not sufficient to have statistical significance, but they do represent the result of a 10 year investigation.

The proposed plan of treatment inaugurated on December 1, 1945, is now recommended as a standard addition to our armamentarium for the treatment of carcinoma of the cervix. If there is reason to expect possible surgical extirpation of the involved tissue, the patient is subjected to a radical Wertheim hysterectomy, with the removal of both tubes and ovaries and the upper one-third or one-half of the vagina, as well as a very careful and thorough bilateral lymphadenectomy to remove all gland-bearing tissue from the external, internal, and obturator gland-bearing chains, along with the entire parametrial and paracervical tissue. This procedure is then followed by roentgen ray therapy, as prescribed by our radiologists, at as early a date as possible and feasible.

The operation is difficult it is true but it can be accomplished by anyone trained in pelvic surgery. With but few minor differences, it is the operation so adequately described by Meigs (4) and Twombly.

The cases reported upon have not been as selective as those of some active clinics. All cases of carcinoma of the cervix in which there was reasonable hope of surgical extirpation of the disease have been accepted. The 89 patients ranged in age from 22 to 76 years. Oddly enough, 12, or approximately 13.4 per cent, of these patients were 30 years of age or younger, and 15 or 16.8 per cent

TABLE I.—INTERNATIONAL CLASSIFICATION OF 89 CASES

	Stage I	*Stage II*	*Total*
No. of patients treated	60	29	89
No. of deaths	8	9	17
No. of survivals	52	20	72
Per cent survived	86.6	68.9	80.8

were past 55 years of age. Their weight ranged from 75 to 200 pounds. Of course, obese patients cannot be dissected as adequately as those of average size, but no such patient has been excluded. Even cases involving patients with cardiac insufficiency have been successfully managed.

RESULTS

Of the 89 cases of proved invasive carcinoma, 60 were stage I (International Classification) and the remaining 29 were stage II, as shown in Table I. Of the 60 stage I cases, 52 patients are alive and free of any evidence of residual disease, making an 86.6 per cent 5 year survival rate; and, of the 29 stage II cases, 20 patients are alive and well, making a 68.9 per cent 5 year survival rate. The over-all survival figure is 80.8 per cent for the 89 patients who were managed 5 or more years ago and who are free of disease at this time.

In this group of 89 patients (Table II), there are 15 in whom nodal involvement was demonstrated, and of these 9 or 60 per cent are alive and well. These patients were also exposed to deep x-ray therapy after recovery from surgery, so that from them one can speculate as to the additional benefit obtained from this therapy. Their 5 year survival rate surpasses that of any known to be reported in the literature.

It is agreed that a patient whose pregnancy is complicated by carcinoma of the cervix has a poorer prognosis than does a woman with that disease who is not pregnant. In the 5 year cases, 4 were connected with pregnancy. One patient was pregnant, and in 3 the diagnosis was made on their second, sixth, and eighth week postpartum examinations. All 4 patients are alive and well. Although the number is small, they deserve attention. Three cases were classified as stage I and 1 as stage II. Patients with cervical stumps are likewise admittedly not as desirably managed as are those with the uteri still in place for radium implantation. In this group, there were 5 such patients, all of whom are alive and well and free of any evidence of disease. Two of these cases were classified as stage I and 3 as stage II. None would be considered an early case of cancer. The results in these two groups of patients have been gratifying.

Patients afflicted with columnar cell carcinoma are admitted by most authorities to have a poorer prognosis than those with squamous cell carcinoma. The cases in the present series justify this belief. Of those patients operated upon 5 or more years ago, there have been 7 with adenocarcinoma, 4 of stage I and 3 of stage II classification, of which only 3 are alive and well. After deletion of the 1 stage II patient who was a hospital fatality, the 5 year survival rate is 50 per cent which is not an encouraging figure. The other 2 patients with stage II disease are dead so that the actual survival rate is 42.8 per cent.

COMPLICATIONS

As reported in other publications, the urinary fistula is the most troublesome complication connected with this procedure. Were it not for this complication, there would be little question regarding the inclusion of this operative procedure in the armamentarium for the treatment of cervical cancers. In this group, there have been 4 ureteral fistulas, or 4.89 per cent of the cases. In 1 patient, a ureter was inadvertently severed at the time of surgery, but it was repaired and subsequent intravenous urograms have shown a normally functioning kidney and ureter. The other fistulas occurred at the expected time of necrosis. Of these 3 fistulas, 1 healed spontaneously. The other 2 patients were successfully managed, and they are living normal lives.

There was 1 very small rectovaginal fistula in a patient with an advanced case, since

deceased. This fistula, however, was so small that it caused no inconvenience and did not preclude sexual activities.

Only 1 patient developed phlebitis, and she was one who had a cervical stump. The phlebitis should have been considered a recurrence of a former thrombophlebitis which the patient had experienced at the time of the subtotal operation.

At the outset of this investigation, a 10 per cent operative mortality was established as the point at which the surgical approach to this disease would be discontinued. In this group, there have been 2 deaths, or 2.46 per cent of the cases. One patient died of an irreversible cardiovascular collapse 24 hours after an extraperitoneal abscess had been opened on the ninth postoperative day, and autopsy revealed evidence of a generalized sepsis. The other patient died from an unmistakable blood transfusion reaction, which became evident just as reperitonization of the operative area was begun at the completion of the dissection.

TABLE II.—CLASSIFICATION IN 15 PATIENTS WITH NODAL METASTASIS OPERATED UPON 5 YEARS OR MORE AGO

	Stage I	*Stage II*	*Total*
No. of cases	4	11	15
No. of deaths	1	5	6
No. of survivals	3	6	9
Per cent survived	75	54.5	60

DISCUSSION

Because of the figures developed from 10 years' efforts, I believe that the time is here to accept surgical management in the treatment of carcinoma of the cervix. In my series, every patient has been subjected to surgery if there was a reasonable hope of surgical extirpation and an adequate gland resection.

The surgical management of a disease having such lethal potentialities was started because of the many failures witnessed in cases which should have been cured and because of the misery noted in women who had been treated by radiation only a few months or many years before. The charge that such complications are unnecessary is unjust, because they result from the radiologist's effort to cure the patient; and, in some cases, these untoward reactions are bound to occur if curative dosages have been administered. All patients' tissues simply do not respond to radiation in a similar manner. Some have almost no skin or vaginal mucosa reaction, while others show irreparable damage. Consequently, the radiologist cannot always exactly predict the result of radiation treatment in some of his patients. The fact that the 2 patients in the present series who were lost at surgery were denied the opportunity of cure by some other mode of therapy could be used as an argument against the surgical approach; but such tragic deaths occur in the practice of any surgeon, regardless of the extent of the operative procedure. Moreover, as recorded by Holzaepfel and Ezell, unexpected fatalities do occur in radiation therapy, and their report substantiates the fact that "all is not well" in cases of irradiation. They cite 4 deaths in patients with involvement, comparable with those of this report, who were lost in preparation for administration of the therapy or directly as the results thereof. Everyone who has used radiation in the treatment of this disease has had a similar experience.

After 10 years' experience, I am convinced that surgery does have a place in the treatment of this disease for two logical reasons: (1) My salvage rate is as good as or better than the rate for those patients treated by other methods in the community. (2) The psychologic effect upon the patient is far more powerful and realistic in those managed by surgery than in the patients treated by radiation. The patient has a visual image of her lesion as a mass—a mass of some size—a mass which exists in the pelvis, eating away at her living body. The average person cannot visualize such a structure being removed from the body by any type of ethereal rays passing through the tissues. They do not have the profound knowledge of nuclear physics which is necessary to comprehend such a phenomenon. However, the patient who has been operated upon has no difficulty in ac-

cepting the fact that she is well, that she has been cured, and that the cancerous mass has been taken from her body and no longer has an opportunity to destroy her. The psychologic effect is far more important and beneficial than is realized or admitted, and it gives these patients additional emotional security.

Cancer is cancer, regardless of the appearance of the cell, as long as invasion can be demonstrated. Some authors believe that adenomatous growths on the cervix are more radioresistant than is the epidermoid type of cancerous growth. This should not be the question of interest at this time. The question of primary importance is, or should be, "how can we cure a malignant growth, so diagnosed, which has its origin in the cervix?" My personal experience forbids treating a patient with radiation and then waiting to see if the tumor is sensitive or resistant to any given form of therapy and indicates that procrastination will defeat the management of these lesions. Consequently, they should be removed surgically without delay, before 3 or more weeks or 2, 10, or 15 months have passed, during which time metastasis can occur and cure then be less likely to be effected.

The salvage rate of the present series is as good as, or better than, that for patients treated by radiologic methods in my community and in other centers throughout the world. I have compared these results with those reported in the tenth volume of the *Annual Report on the Results of Treatment in Carcinoma of the Uterus*, in which statements of results for carcinoma of the cervix obtained in 1948 and in previous years have been collated from 84 institutions in 20 different countries. Relative apparent recovery rates for the latest 5 years have been estimated for 6,660 patients with stage I carcinoma, of whom 4,324, or 64.9 per cent, were alive and without evidence of the disease, and for 13,294 patients with stage II disease, of whom 6,109, or 46.0 per cent, were alive without evidence of the disease. The rates of 86.6 per cent for 5 year survival of patients with stage I and of 68.9 per cent for 5 year survival of patients with stage II, for this series of 89 patients, compare favorably with the statistically significant figures mentioned which are from clinics large enough to report on 100 or more cases treated in their institutions. The comparative figures speak for themselves and encourage my belief in surgical management of carcinoma of the cervix.

SUMMARY AND CONCLUSIONS

1. The reasons for my surgical investigation have been stated.

2. The proposed therapeutic procedure has been outlined.

3. The results in patients operated upon 5 or more years ago have been compared with statistical reports of other clinics.

4. The cases of nodal metastasis with 60 per cent of the patients having survived 5 years warrant serious consideration.

5. The observation relative to the difference in the emotional stability of the patients operated upon compared with those treated formerly by radiation only is significant.

REFERENCES

1. Annual Report of the Results of Treatment in Carcinoma of the Uterus. Vol. 10. Stockholm: Radiumhemmet, 1955.
2. Holzaepfel, John H., and Ezell, Harry E. Sites of metastases of uterine carcinoma. Am. J. Obst., 1955, 69: 1027.
3. Meigs, Joe V. Carcinoma of the cervix; the Wertheim operation. Surg. Gyn. Obst., 1944, 78: 195.
4. Idem. Surgical Treatment of Cancer of the Cervix. New York: Grune & Stratton, 1954.
5. Twombly, Gray H. Technique of the Radical hysterectomy for carcinoma of the cervix. Cancer, 1950 3: 975.

OMPHALOMESENTERIC DUCT ANOMALIES

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INCOMPLETE OBLITERATION of the embryonic omphalomesenteric duct may lead to the formation of a number of interesting congenital abnormalities capable of producing a wide variety of clinical disturbances.

Early in embryonic life, about the third week, the omphalomesenteric duct serves as a communication between the gut of the embryo and the yolk sac. A progressive narrowing of the duct begins during the fifth week, as placental nutrition becomes established. This process of obliteration generally is completed during the seventh week, the 7 millimeter stage.

The duct may persist in its entirety, being patent from the intestine to the umbilicus, or it may only partially obliterate, forming a diverticulum which is connected to the umbilicus by a fibrous band. A segment of the duct may remain as a cyst at some point along the tract from the intestine to the umbilicus. The formation of a Meckel's diverticulum, arising from the antimesenteric border of the ileum and free of umbilical attachment, is by far the commonest result of incomplete omphalomesenteric duct obliteration. It has been estimated from autopsy series that Meckel's diverticulum may occur in from 1 to 3 per cent of the population. It is apparent, from these statistics and the relatively small number of cases in which pathologic diverticula are encountered, that a Meckel's diverticulum may be expected to produce symptoms in only a small number of the persons in whom it occurs.

The number of published reports of large series of symptomatic cases is small. Most of these reports have come from hospitals which are exclusively pediatric or largely devoted to the care of adult patients. For this reason, it has seemed desirable to record the combined pediatric and adult experience at the Indiana University Medical Center with 46 symptomatic cases of omphalomesenteric duct anomalies. All but 2 of these cases were seen during an 18 year period, from 1938 to 1956.

In 10 cases, the omphalomesenteric duct remained patent from the ileum to the umbilicus (Table I). The duct was open at the umbilicus in 6 of these cases and, in 5 of them intussusception of ileum through the inverted duct onto the abdominal wall had occurred. The duct was closed at the umbilicus with granulation tissue or skin in 4 cases. In 5 cases, a diverticulum was attached to the umbilicus by a fibrous band. A Meckel's diverticulum was found in 31 cases and was unattached in all but 3 in which an internal hernia was formed by attachment of Meckel's diverticulum to an adjacent structure other than the umbilicus.

The principal symptoms produced by these malformations were intestinal obstruction, abdominal pain, and melena and anemia (Table II). They were encountered with approximately equal frequency. The mechanism for intestinal obstruction varied. Inversion of the diverticulum which acted as the leading point for an intussusception was the most common.

The ages at which symptoms occurred are of interest. Although the ages of the patients included in this study ranged from 1 day to 69 years, the majority of the patients (78 per cent) were 15 years of age or younger (Table III). Approximately one-third of the patients were in their first year of life. Only 1 of the patients had been born prematurely and none of the patients were negroes.

Thirty-seven of the 46 patients were males (80 per cent) and 9 were females. The male preponderance was even greater in the group

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TABLE I.—TYPES OF OMPHALOMESENTERIC DUCT ANOMALIES ENCOUNTERED

		No. of cases
Persistent omphalomesenteric duct		10
Intussusception of ileum through duct	5	
Duct open at umbilicus without prolapse	1	
Duct closed at umbilicus with granulation tissue	1	
Duct closed at umbilicus with skin	3	
Diverticulum attached to umbilicus by fibrous band		5
Meckel's diverticulum		31
Diverticulitis	12	
Melena and anemia	10	
Leading point of intussusception	6	
Internal hernia from attachment to adjacent structure	3	
Total		46

of patients in whom gastric mucosa was found in the diverticulum or duct. In this group with gastric mucosa, 16 of 18 patients were males. The presence of gastric mucosa in these malformations is of considerable importance with respect to the production of symptoms. It was found to be the most frequently encountered type of mucosa other than ileal (Table IV).

Because of the wide variance in the character of the clinical problems presented by these malformations, each major group will be considered separately.

PERSISTENT OMPHALOMESENTERIC DUCT

Intussusception of ileum through persistent omphalomesenteric duct. The prolapse or intussusception of ileum through a patent omphalomesenteric duct onto the abdominal wall is one of the most dramatic as well as one of the most terrifying complications of this general type of congenital malformation. This complication occurred in 5 cases and in all of them during the first month of life (Table V). All but 1 of the patients were males. In 3 of the cases, all of those with intussusception at 10 days of age or older, a fecal fistula at the umbilicus preceded the prolapse.

TABLE II.—TABULATION OF CHIEF COMPLAINTS

		No. of cases
Intestinal obstruction		13
Intussusception	6	
Band to umbilicus	4*	
Internal hernia from Meckel's diverticulum attachment	3	
Abdominal pain		13
Melena and anemia		12
Invagination of ileum onto abdominal wall		5
Fecal fistula at umbilicus		1
Umbilical hernia		1
Associated anomaly (ileal atresia)		1
Total		46

*Secondary volvulus of the diverticulum with ischemia and gangrene of the diverticulum occurred in 2 of these cases.

The prolapse of inverted intestine was T-shaped with 2 orifices presenting in 3 cases and I-shaped but with 1 orifice in 2 cases. In 1 of the cases, the T-shaped prolapse was discovered at birth on top of an omphalocele.

Other major congenital abnormalities were encountered in 2 cases. The patient with the omphalocele was also found to have malrotation of the intestines, cleft palate, and abnormally placed ureterovesical junctions bilaterally. This patient, a prematurely born infant, has survived operative correction of the omphalomesenteric duct anomalies and omphalocele, repair of the cleft palate, and reimplantation of both ureters. The other patient was admitted to the hospital at 6 days of age in heart failure due to congenital heart disease. The infant was unable to survive outside of an oxygen tent. A fecal fistula at the umbilicus occurred at 21 days of age and, at 29 days, inverted ileum prolapsed through the opening onto the abdominal wall. This defect was corrected by operation with relative ease. However, the infant's cardiac status became more precarious and he died in heart failure a short time later.

Operation reduction of the intussusception followed by resection of the omphalomesenteric duct was carried out in 4 cases, and all but the patient with congenital heart disease recovered. The patient with the associated omphalocele was managed successfully by resection of the omphalocele, the prolapsed ileum, and the omphalomesenteric duct. Ileal continuity was re-established by means of an end-to-end anastomosis and the omphalocele defect was repaired by direct approximation of the separated layers of abdominal wall.

Persistent omphalomesenteric duct without prolapse. An opening of the duct at the umbilicus, with a fecal fistula, was found in only 1 of the 5 cases of persistent omphalomesenteric duct without prolapse (Table VI). In all of these cases the duct was patent from

intestine to umbilicus. An umbilical hernia was present in 2 of the cases. The umbilical end of the duct was closed in 4 cases, by granulation tissue in 1 and by skin in 3.

Symptoms leading to the discovery of the persistent duct occurred during the early weeks and months of life in all of these cases. All 5 infants were males, giving a 9 to 1 ratio of males to females in these 10 patients with persistent omphalomesenteric duct.

In 2 cases, the persistent duct was discovered accidentally at the time of operation and did not directly produce the difficulty for which the patient was operated upon. The duct was found at the time of operation for congenital ileal atresia at 5 days of age in 1 case. The atresia was located in the ileum just distal to the persistent omphalomesenteric duct. Although it was adjacent to the atresia, it did not contribute to the intestinal obstruction and was essentially an incidental finding. This patient did not survive resection of the atretic ileum with the persistent duct followed by an end-to-end anastomosis of ileum. In the other case, the duct was discovered during repair of an umbilical hernia. It was managed successfully by resection of the omphalomesenteric duct with the umbilicus.

Operation was carried out on 1 infant at 5 weeks of age because of a fecal fistula at the umbilicus. The omphalomesenteric duct was resected and was found to be lined with colonic mucosa. The remaining 2 infants were operated upon because of severe melena and anemia with secondary umbilical disorders. An indurated umbilical mass had appeared at the site of an umbilical hernia in one of these patients. The other patient was also having difficulty with a bloody drainage which was coming from an area of granulation tissue at the umbilicus. Both patients were treated by resection of the omphalomesenteric duct and umbilicus and both ducts were found to be lined with gastric as well as ileal mucosa. All patients in this group, except the one with associated ileal atresia, survived operative removal of persistent omphalomesenteric duct.

TABLE III.—AGE AT OCCURRENCE OF SYMPTOMS

	No. of patients
Under 1 year	15
1–2 years	5
3–5 years	1
6–10 years	8
11–15 years	7
16–25 years	4
Over 25 years	6

DIVERTICULUM ATTACHED TO UMBILICUS BY FIBROUS BAND

An intermediate type of malformation consisting of a diverticulum which was attached to the umbilicus by a fibrous band was found in 5 cases (Table VII). Symptoms, leading to operation, occurred in the first decade of life in all but 1 of these patients. This 1 patient was 23 years old at onset of symptoms and was the only female in the group.

The patient's symptoms were due to intestinal obstruction in 4 of the 5 cases. The obstruction was caused by a loop of small intestine being caught over the band to the umbilicus. In 2 of these cases, a volvulus of the diverticulum also occurred with significant ischemia of the diverticulum. The diverticulum of 1 of these patients was gangrenous and disintegrated during removal. All 4 patients were treated by lysis of the band and resection of the diverticulum.

The symptoms were of abdominal pain from inflammatory peritoneal irritation in 1 patient. In this unusual case, a large diverticulum arose from the side of the appendix and its distal end was attached to the umbilicus by a fibrous band. Both the diverticulum and the appendix were acutely inflamed and both were resected with the fibrous band. This case was reported in 1936 by Hadley and Cogswell.

TABLE IV.—TYPES OF MUCOSA FOUND IN 37 OMPHALOMESENTERIC DUCT ANOMALIES STUDIED MICROSCOPICALLY

	No. of cases
Ileal	34
Gastric	18
Colonic	3
Pancreatic	2
Duodenal	1
Adenomatous polyp	1

TABLE V.—INTUSSUSCEPTION OF ILEUM THROUGH PERSISTENT OMPHALOMESENTERIC DUCT

Case	*Age*	*Sex*	*Year*	*Appearance of invaginated ileum*	*Operation*	*Associated anomalies*	*Mucosal lining of duct*	*Result*	*Remarks*
1	1 day	F	1954	T-shaped (on top of omphalocele)	Resection of O-M duct and ileum with end-to-end anastomosis. Repair of omphalocele	Omphalocele, cleft palate, malrotation of intestines, anomalous insertion of ureters into bladder	Ileal	Recovered	Premature infant. Palate and ureteral malformations have been repaired successfully
2	2 days	M	1939	I-shaped	Reduction of intussusception and resection of O-M duct			Recovered	
3	10 days	M	1954	T-shaped	Reduction of intussusception and resection of O-M duct		Ileal	Recovered	Fecal fistula prior to intussusception
4	12 days	M	1951	T-shaped	Reduction of intussusception and resection of O-M duct		Ileal	Recovered	Fecal fistula prior to intussusception
5	1 month	M	1949	I-shaped	Reduction of intussusception and resection of O-M duct	Multiple cardiac anomalies		Died	Admitted to hospital in heart failure at 6 days of age. Fecal fistula at 21 days and prolapse at 29 days of age. Death due to congenital heart disease

All 5 patients in this group were treated by operation and all 5 recovered.

MECKEL'S DIVERTICULUM

Diverticulitis. Acute inflammation of the diverticulum was the most frequently encountered cause of symptoms in the group of patients with Meckel's diverticulum (Table VIII). In some of the cases, the inflammation was of a nonspecific nature, while in others it presumably was due to peptic ulceration resulting from the presence of gastric mucosa in the diverticulum. Gastric mucosa was identified in the diverticulum in 5 cases. In 1 additional case, the adjacent ileum was greatly inflamed distal to the diverticulum in a manner characteristic of peptic ulceration. However, the mucosa of the diverticulum unfortunately was destroyed by the inflammatory process and the presence or absence of gastric mucosa could not be established. In 2 of the patients with gastric mucosa in the diverticulum, a perforated peptic ulcer of the diverticulum was found.

The age range of these patients with diverticulitis was considerably older than that encountered in any of the other groups in this study. All of the patients were 9 years of age or older and half of them were over 21 years of age. Five of the patients were females and 7 were males. Four of the 5 patients with gastric mucosa in the diverticulum were males. Four of the 6 patients with ileal mucosa only were females. This observation is of interest since only 9 females were found in the entire series of 46 cases.

Resection of adjacent ileum with the diverticulum was necessary in 2 cases. The remaining 10 patients were managed by resection only of the diverticulum. Incidental appendectomy was carried out in 9 cases. All 12 patients recovered.

Melena and anemia. Severe melena and anemia dominated the clinical picture in 10 of the patients with Meckel's diverticulum (Table IX). These findings were presumed to be due to bleeding peptic ulcers produced by the acid secretions of the gastric mucosa of the diverticulum. Gastric mucosa was identified in 8 of the diverticula. In 1 of the remaining 2 cases, a firm mass was palpated in the tip of the diverticulum at the time of

TABLE VI.—PERSISTENT OMPHALOMESENTERIC DUCT WITHOUT PROLAPSE

Case	*Age*	*Sex*	*Year*	*Status of duct at umbilicus*	*Chief complaint*	*Operation*	*Associated anomalies*	*Mucosal lining of duct*	*Result*	*Remarks*
1	5 days	M	1946	Closed (skin covered)	Ileal atresia	Resection atretic ileum and O-M duct. End-to-end anastomosis	Ileal atresia	Ileal	Died	Atresia of ileum just distal to O-M duct
2	5 weeks	M	1947	Open	Fecal fistula at umbilicus	Resection O-M duct		Colonic	Recovered	Large umbilical cord dropped off at 1 month of age
3	5 months	M	1936	Closed (skin covered)	Melena, anemia, and indurated umbilical mass	Resection O-M duct and umbilicus	Umbilical hernia	Ileal, gastric	Recovered	Umbilical cord large at birth. It protruded at 1 month and later became indurated. RBC was 2.2 million and Hgb. 3.7 gms.
4	11 months	M	1954	Closed (granulation covered)	Melena, anemia, and bloody drainage at umbilicus	Resection O-M duct and umbilicus		Ileal, gastric	Recovered	Umbilicus indurated with granulation tissue. Bloody discharge. RBC was 2.6 million and Hgb. 7.5 gms.
5	14 months	M	1954	Closed (skin covered)	Umbilical hernia	Resection O-M duct and umbilicus	Umbilical hernia	Ileal	Recovered	Duct attached to hernia sac. Patent to this point

operation. If a larger number of sections through the diverticulum had been taken in both cases, it is probable that an area of gastric mucosa would have been found.

Nine of the 10 patients were males. Although there was a rather wide range in the ages of the patients at the onset of symptoms, 7 of them were 15 years of age or younger. In addition to melena and anemia, abdominal pain was encountered in 4 cases and repeated episodes of fainting occurred in 2 cases. The consistently severe degree of anemia encountered in this group of patients is shown by the red blood count and hemoglobin determinations.

Characteristic areas of peptic ulceration were identified in 4 cases. In 1 case, the ulcer also had perforated, thus leading to the formation of an abscess nearby. One patient complained that abdominal pain occurred approximately 2 hours after meals and that this pain occasionally was relieved by bicarbonate of soda.

Resection of Meckel's diverticulum alone was carried out in 7 cases. In 1 case a perforated diverticulum was resected with an associated abscess. Resection of adjacent ileum with the diverticulum was necessary in 2 cases. End-to-end anastomoses were used to re-establish ileal continuity in both cases. In 1 case, there was marked inflammation and edema of the ileum distal to the diverticulum. Only gastric mucosa was found in the other case and the ulcer occurred in the ileum near the base of the diverticulum. All 10 patients recovered with relief of their symptoms.

As the leading point of an intussusception. A Meckel's diverticulum served as the leading point for an intussusception in 6 cases (Table X). Four of the patients were in their first year, and the other 2 were 8 and 13 years of age. Five of the 6 patients were males.

An ileocolic type of intussusception was found in all but 1 patient. This patient had a gangrenous ileoileal intussusception which was managed by resection of the diverticulum and involved intestine followed by an end-to-end anastomosis. This patient had a temperature of 104 degrees Fahrenheit with marked elevation of the white blood count on admission to the hospital.

TABLE VII.—DIVERTICULUM ATTACHED TO UMBILICUS BY FIBROUS BAND

Case	*Age*	*Sex*	*Year*	*Symptoms*	*Findings at operation*	*Operation*	*Mucosal lining of diverticulum*	*Result*	*Remarks*
1	15 months	M	1951	Intestinal obstruction	Loop of ileum obstructed by band. Volvulus of diverticulum with gangrene	Lysis of band; resection of diverticulum	Autolysis of mucosa	Recovered	Gangrenous diverticulum disintegrated while being resected
2	2 years	M	1949	Intestinal obstruction	Loop of ileum obstructed by band	Lysis of band; resection of diverticulum		Recovered	Patient was mentally retarded
3	7 years	M	1945	Intestinal obstruction	Loop of ileum obstructed by band	Lysis of band; resection of diverticulum	Ileal, gastric	Recovered	
4	9 years	M	1934	Abdominal pain	Diverticulitis and appendicitis. Diverticulum arose from side of appendix and tip was attached by band to umbilicus	Resection of band, diverticulum, and appendix	Colonic	Recovered	Appendix was 4 cm. long. Diverticulum arose from appendix 1.5 cm. from its base. The diverticulum was 9 cm. long and its tip was attached by a fibrous band to the umbilicus. Both appendix and diverticulum were acutely inflamed
5	23 years	F	1940	Intestinal obstruction	Loop of ileum obstructed by band. Volvulus of diverticulum with ischemia	Lysis of band; resection of diverticulum		Recovered	Malrotation of the intestines also found

One of the 5 patients with an ileocolic intussusception was managed by reduction of the intussusception without resection of the diverticulum. This patient was quite ill and had been admitted to the hospital with a temperature of 106 degrees Fahrenheit. The Meckel's diverticulum was resected following reduction of the intussusception in the other 4 ileocolic cases. A perforated diverticulum was discovered in 1 of these cases. The diverticulum contained gastric mucosa. All 6 of the patients in this group recovered.

It is of interest that heterotopic tissue of a type more bulky than ileal or colonic mucosa was found in 4 of the 5 diverticula studied. Gastric or pancreatic tissue, or both, was discovered in the diverticulum in 3 patients. One patient was found to have an adenomatous polyp with a narrow pedicle which arose from the wall of the Meckel's diverticulum. Pancreatic tissue was found in only 2 diverticula both of which acted as the leading point for an intussusception.

Ring for internal hernia formed by attachment of Meckel's diverticulum to adjacent structure. Intestinal obstruction occurred in 3 cases due to the herniation of a loop of small intestine through a ring produced by the attachment of a Meckel's diverticulum to an adjacent structure other than the umbilicus (Table XI). The incarcerated loop of intestine was gangrenous in 2 of the patients. All 3 of the patients in this group died. Two were in extremis on admission to the hospital and were not operated upon. The condition of the third patient was little better. This patient, a 21 month old child, was admitted to the hospital with a temperature of 105 degrees Fahrenheit and a history of fecal vomiting of 4 days' duration. The tip of the inflamed and hemorrhagic Meckel's diverticulum was adherent to the base of the mesentery. The obstruction was relieved and the inflamed diverticulum was resected. The patient died shortly after operation.

One of the 2 patients not treated by operation was 1 month old and had been cyanotic since birth. At autopsy, the tip of the diverticulum was found to be adherent to the peritoneum of the iliac fossa a short distance

TABLE VIII.—MECKEL'S DIVERTICULUM WITH DIVERTICULITIS

Case	*Age*	*Sex*	*Year*	*Symptoms*	*Operation*	*Mucosal lining of diverticulum*	*Result*	*Remarks*
1	9 years	M	1940	Abdominal pain	Resection of Meckel's diverticulum*	Ileal, gastric	Recovered	Bilateral inguinal hernia with undescended testis on the right
2	10 years	M	1943	Abdominal pain	Resection of Meckel's diverticulum*	Ileal	Recovered	Marked inflammation. Temperature 103° and WBC 17,000
3	11 years	M	1941	Abdominal pain	Resection of perforated Meckel's diverticulum	Ileal, gastric, duodenal	Recovered	Perforation of diverticulum with feces pouring into peritoneal cavity. Generalized peritonitis
4	13 years	F	1942	Abdominal pain	Resection of Meckel's diverticulum*	Ileal	Recovered	Umbilical hernia was repaired at 3 years of age
5	15 years	M	1948	Abdominal pain	Resection of perforated Meckel's diverticulum with 15 cm. of ileum	Ileal, gastric	Recovered	Perforation of diverticulum; ulcer near base with inflammatory mass
6	15 years	F	1945	Abdominal pain	Resection of Meckel's diverticulum*	Ileal, gastric	Recovered	Marked edema of diverticulum with peptic ulceration
7	21 years	M	1939	Abdominal pain	Resection of inflamed ileum and Meckel's diverticulum	Destroyed by inflammation	Recovered	Marked inflammation of diverticulum and adjacent ileum
8	24 years	F	1938	Abdominal pain	Resection of Meckel's diverticulum*	Ileal	Recovered	Diverticulum 9 cm. long with marked acute inflammation
9	32 years	F	1938	Abdominal pain	Resection of Meckel's diverticulum*	Ileal	Recovered	Marked distention and inflammation of diverticulum
10	34 years	M	1941	Abdominal pain	Resection of Meckel's diverticulum*	Ileal, gastric	Recovered	Recurrent attacks of abdominal pain of 10 years' duration
11	34 years	M	1941	Abdominal pain	Resection of Meckel's diverticulum*	Ileal	Recovered	Acute inflammation of diverticulum with lumen full of purulent material
12	53 years	F	1940	Abdominal pain	Resection of Meckel's diverticulum*	Ileal	Recovered	Diverticulum large and inflamed. WBC 13,000

*Appendix also removed.

below the cecum. The gangrenous loop of incarcerated small intestine had perforated, producing generalized peritonitis. Transposition of the great vessels was discovered to be the cause of the cyanosis. The other patient was 10 years of age and the diverticulum was adherent to an adjacent loop of ileum. He also had had difficulties with portal hypertension and esophageal varices secondary to a cavernous portal vein. Several previous operative attempts had been made to control the portal hypertension. These included splenectomy, anastomosis of a mesenteric vein to the renal vein, vagotomy, and esophageal resection. He died before operative relief of the obstruction could be undertaken. On postmortem examination, the incarcerated loop of intestine was discovered to be gangrenous.

DISCUSSION

Considerable variation in the types of omphalomesenteric anomalies may be found in some of the larger series of symptomatic cases which have been reported. Some of the variance may be traced to the character of the institution from which the reported experience is derived, whether it is a children's hospital or one largely devoted to the care of adults. In this regard, it should be noted that the incidence of patent omphalomesenteric duct problems, intestinal obstruction, and peptic ulceration is greater in the pediatric age group, whereas diverticulitis and vague symptoms of abdominal pain appear to occur more frequently in adults. A relatively high incidence of patent omphalomesenteric duct malformations was found in this series and the number of instances of

TABLE IX.—MECKEL'S DIVERTICULUM WITH MELENA AND ANEMIA

Case	*Age*	*Sex*	*Year*	*Symptoms*	*R.B.C. and Hgb.*	*Operation*	*Mucosal lining of diverticulum*	*Result*	*Remarks*
1	4 months	M	1949	Melena, anemia	R 3.0*	Resection of abscess mass with perforated Meckel's diverticulum	Ileal, gastric	Recovered	Perforated ulcer found with abscess adherent to colon
2	17 months	M	1951	Melena, anemia	R 1.7 H 4.5	Resection of Meckel's diverticulum	Ileal	Recovered	Distal end of M. D. felt to be solid at operation
3	4 years	M	1953	Melena, anemia, abdominal pain	R 2.8 H 5.5	Resection of inflamed ileum and Meckel's diverticulum. End-to-end anastomosis	Ileal, gastric	Recovered	Diverticulum and adjacent ileum inflamed. Ulcer in M. D. with crater through wall
4	6 years	M	1953	Melena, anemia	R 1.9 H 7.5	Resection of Meckel's diverticulum	Ileal, gastric	Recovered	Ulcer at mouth of diverticulum
5	8 years	M	1944	Melena, anemia	R 1.0 H 2.8	Resection of Meckel's diverticulum	Ileal, gastric	Recovered	Appendix also removed
6	15 years	M	1945	Melena, anemia, abdominal pain	H 7.5	Resection of Meckel's diverticulum	Ileal, gastric	Recovered	Abdominal pain occurred 2 hours after meals and was occasionally relieved by soda
7	15 years	M	1949	Melena, anemia, abdominal pain, fainting	R 1.7 H 4.0	Resection of Meckel's diverticulum	Ileal, gastric, colonic	Recovered	
8	21 years	F	1955	Melena, anemia, fainting	R 1.3 H 4.6	Resection of ileum and Meckel's diverticulum. End-to-end anastomosis	Gastric	Recovered	Ulcer in ileum at base of Meckel's diverticulum
9	30 years	M	1946	Melena, anemia, abdominal pain	R 1.9 H 5.2	Resection of Meckel's diverticulum	Ileal, gastric	Recovered	Diverticulum 5 inches long. History of operation at 12 years for unusual umbilical abnormality
10	69 years	M	1951	Melena, anemia	R 2.0 H 7.5	Resection of Meckel's diverticulum	Ileal	Recovered	Melena and anemia cleared by operation. No other abnormalities found

*Transfused elsewhere prior to admission.

TABLE X.—MECKEL'S DIVERTICULUM AS LEADING POINT OF INTUSSUSCEPTION

Case	*Age*	*Sex*	*Year*	*Type of intussusception*	*Operation*	*Mucosal lining of diverticulum*	*Result*	*Remarks*
1	5 months	M	1947	Ileocolic	Reduction of intussusception		Recovered	Temperature 106° on admission
2	6 months	M	1947	Ileocolic	Reduction of intussusception. Resection perforated Meckel's diverticulum	Ileal, gastric	Recovered	Perforation of Meckel's diverticulum at junction of ileal and gastric mucosa
3	9 months	M	1954	Ileoileal	Resection of intussusception with gangrenous Meckel's diverticulum. End-to-end anastomosis	Ileal	Recovered	Temperature 104° and WBC 29,000 on admission
4	11 months	M	1948	Ileocolic	Reduction of intussusception. Resection of Meckel's diverticulum	Ileal, pancreatic	Recovered	
5	8 years	M	1941	Ileocolic	Reduction of intussusception. Resection of Meckel's diverticulum	Ileal, gastric, pancreatic	Recovered	
6	13 years	F	1942	Ileocolic	Reduction of intussusception. Resection of Meckel's diverticulum	Ileal, adenomatous polyp	Recovered	Patient mentally deficient. Diverticulum 3.5 cm. long and 2.5 cm. in diameter. Adenomatous polyp 2 cm. in diameter arising from wall of M. D. Pedicle of polyp 1 cm. long and 0.8 cm. in diameter

TABLE XI.—RING FOR INTERNAL HERNIA FORMED BY ATTACHMENT OF MECKEL'S DIVERTICULUM TO ADJACENT STRUCTURE

Case	*Age*	*Sex*	*Year*	*Symptoms*	*Area of attachment*	*Operation*	*Mucosal lining of diverticulum*	*Associated anomalies*	*Result*	*Remarks*
1	1 month	M	1950	Intestinal obstruction	Peritoneum 2 cm. below cecum	None		Transposition of great vessels	Died	Ileum herniated. Ring created by diverticulum attachment with strangulation of loop, perforation and peritonitis. Infant cyanotic since birth and in extremis on admission
2	21 months	M	1948	Intestinal obstruction	Base of mesentery	Relief of obstruction. Resection of gangrenous Meckel's diverticulum	Ileal		Died	Fecal vomiting of 4 days' duration. Temperature 105° on admission
3	10 years	M	1954	Intestinal obstruction	Adjacent loop of ileum	None		Cavernous portal vein with portal hypertension	Died	Loop of ileum herniated through ring created by diverticulum attachment. Loop gangrenous. Patient had had multiple operations for attempted relief of portal hypertension

prolapse or intussusception of ileum through a persistent omphalomesenteric duct was unusually large.

It was somewhat of a surprise that no negro patients were encountered in this series. An apparently lower incidence of Meckel's diverticulum in the negro race also is suggested by the report of Michel and his associates from the Charity Hospital in New Orleans. Although approximately 68 per cent of the patients admitted to that institution are negroes, only 25 per cent of the patients in whom a Meckel's diverticulum was discovered were negroes.

Omphalomesenteric duct anomalies appear to occur with equal frequency in males and females. However, in symptomatic cases there is a rather marked male predominance. Soderlund found a male to female ratio of 7 to 1 in 54 symptomatic cases in the pediatric age group from the Kronprinsessan Lovisas Barnsjukhus in Stockholm, while in a group of 61 children from the same institution with an asymptomatic Meckel's diverticulum, encountered as a random finding, 32 were males and 29 were females. Gross has reported a male to female ratio of 3 to 1 in a group of 149 symptomatic cases from the Children's Hospital in Boston. A smaller ratio of only 2 to 1 was encountered by Aitken in 73 symptomatic cases from the Royal Hospital for Sick Children in Glasgow. The series of 100 patients reported by Michel and his associates from predominantly adult institutions includes 29 asymptomatic cases. Only 15 of their patients had symptoms of bleeding or intestinal obstruction. Forty-eight of their patients were males and 52 were females.

Although the over-all male to female ratio in this series from the Indiana University Medical Center is 4 to 1, some interesting observations may be made on breaking down the sex incidence with respect to the type of malformation and the character of the symptoms. A marked male predominance of 9 to 1 was found in the persistent omphalomesenteric duct group. A similarly marked male predominance of 9 to 1 occurred in the group of 18 patients in whose ducts or diverticula

gastric mucosa was found. In addition, 11 of the 13 patients with symptoms of intestinal obstruction were males. Only in the diverticulitis group was there a fairly even sex distribution. In the 6 patients in this group with ileal mucosa only, an actual female predominance of 2 to 1 existed.

In contrast to some other types of congenital malformation, prematurity was found to be an insignificant factor in omphalomesenteric duct anomalies. Only 1 patient in this series was born prematurely. Additional congenital malformations also seemed to occur less frequently and were concentrated in 2 groups of cases. Seven patients had other anomalies. In 2 cases, these additional malformations were the direct cause of the patient's death and, in 2 other cases, the associated abnormalities would have proved fatal in a short period if the patients had not first succumbed to strangulated internal hernia secondary to the attachment of the diverticulum to an adjacent structure. Other anomalies were discerned in 3 of the 10 patients with persistent omphalomesenteric ducts. As might be expected, umbilical malformations appeared to occur more commonly in patients with omphalomesenteric duct anomalies. Three patients had umbilical hernias and 1 had an omphalocele.

The literature concerning intussusception of ileum through a persistent omphalomesenteric duct was reviewed by the author and Shumacker (15) in 1952. Up to that time only 33 cases had been reported and only 3 of the patients had recovered. The first long term postoperative survival had been reported in 1947 by Kittle, Jenkins, and Dragstedt. Other successes had been reported by Bronaugh and by Arnheim. Since 1952, reports of 7 additional cases have appeared in the literature. The prolapse was T-shaped in 4 of these cases and I-shaped in 3. Five of these patients recovered—including the second case of Gandry and the patients of Allen and Fitchett, Hagemeyer, Brown and Cain, and Kirtland. The first case of Gandry and the patient reported by Lowman and his associates died. The case of Allen and Fitchett is of interest because of its similarity to Case 1 reported here. The prolapse in their case was T-shaped and occurred through a persistent omphalomesenteric duct which was located on top of an omphalocele. Their patient, a negro infant, also was born prematurely. In view of the rather limited number of reported cases, the experience at the Indiana University Medical Center with 5 cases is surprisingly large, and the recovery of 4 of the patients compares quite favorably with the reported experience in the literature. The single fatality was due to severe, pre-existing heart failure and congenital heart disease rather than to a complication of the repair of the omphalomesenteric duct malformation.

The origin of an omphalomesenteric duct abnormality from the appendix is rather unique. A case in which the persistent duct arose from the tip of the appendix and was attached to the umbilicus was reported in 1951 by Singleton and King. They found 4 other cases in the literature, including the case in this series which was reported in 1936 by Hadley and Cogswell. The diverticulum or duct arose from the tip of the appendix in 1 of these cases and, in the other 3, it arose from the side or base of the appendix.

The finding of a relatively solid type of tissue in the Meckel's diverticulum (gastric mucosa, pancreatic tissue, or adenomatous polyp) in 4 of the 5 diverticula which acted as the leading point for an intussusception is of interest. This finding suggests that the presence of a more solid type of tissue in a Meckel's diverticulum may render it more likely to invert and act as the leading point for an intussusception. Pancreatic tissue was found in only 2 diverticula in this series and in both cases the diverticulum had acted as the leading point for an intussusception. A similar finding was reported by Migliaccio and Begg. Of their series of 50 cases, 21 were symptomatic. Pancreatic tissue was found in the diverticulum in 2 cases and in both of them intussusception had occurred.

A striking difference exists between the nature of the intestinal obstruction produced

in those cases in which the anomaly is adherent by a fibrous cord to the umbilicus and in those cases in which it is adherent to an adjacent structure other than the umbilicus. A nonstrangulating type of obstruction seems to result from the winding of a loop of small intestine about the fibrous cord attached to the umbilicus, and the accompanying mortality in surgically managed cases is relatively low. On the other hand, the internal hernia produced by the attachment of the diverticulum to an adjacent structure is unusually lethal. The ring formed by the attached diverticulum is a constricting one, and generally produces a strangulating type of obstruction with early gangrene, perforation, and death. All 3 of the patients in this series with this type of obstruction died, and only 1 lived long enough to be operated upon. In contrast to this dismal picture, all of the 4 patients with obstruction from a band passing to the umbilicus from a diverticulum recovered. Impairment of the blood supply to the involved intestine did not occur in any of these patients. This observation is further emphasized by the findings of Aitken. In his series, intestinal obstruction occurred in 3 cases in which the diverticulum was attached to the umbilicus by fibrous cord, and all 3 recovered. However, in 13 of his cases, obstruction resulted from the internal hernia formed by the attachment of the diverticulum to the mesentery either directly or by fibrous band. Seven of these 13 patients died.

Forty-four patients were managed by operation, and 2 patients died before operation could be carried out. Resection of a duct or diverticulum was performed in 28 cases. In 6 cases, a duct or diverticulum was resected with varying lengths of ileum because of difficulties arising from the presence of the omphalomesenteric duct anomaly. In 1 case, ileal resection was carried out because of ileal atresia and the near-by patent omphalomesenteric duct was excised because of its proximity to the area of ileal atresia. Reduction of an intussusception, either onto the abdominal wall or into the large intestine, was effected in 8 cases prior to the resection of the duct or diverticulum. In 1 case, only reduction of an ileocolic intussusception was carried out.

TABLE XII.—RESULTS OF OPERATIVE MANAGEMENT OF SYMPTOMATIC OMPHALOMESENTERIC DUCT ANOMALIES

Institution	*Year of report*	*No. of cases*	*No. of deaths*	*Mortality, per cent*
Royal Hospital for Sick Children, Glasgow (1)	1953	73	15	21
Children's Hospital, Boston (7)	1953	128	21	16
Kronprinsessan Lovisas Barnsjukhus, Stockholm (17)	1956	54	8	15
Indiana University Medical Center	1956	44	3	7

All but 3 of the 44 patients who were operated upon recovered. Two of 3 deaths were due primarily to additional congenital malformations, congenital heart disease in one case and complications of the management of atresia of the ileum in the other. The 1 death which was due to the presence of an omphalomesenteric duct anomaly involved a patient with intestinal obstruction of 4 days' duration. The obstruction was secondary to an incarcerated internal hernia. A loop of small intestine was trapped by a ring which was formed by the attachment of a Meckel's diverticulum to the base of the mesentery. The operative mortality of 7 per cent compares favorably with that reported in other larger series (Table XII). When considering the mortality risk associated with the care of these malformations, one constantly must bear in mind the number and character of the various types of abnormality encountered. It appears from the reported experience in the larger series that the greatest hazard of mortality is faced in the management of those patients with an intestinal obstruction due either to an internal hernia produced by the attachment of a Meckel's diverticulum to an adjacent structure other than the umbilicus or to an intussusception with a Meckel's diverticulum acting as a leading point. Although intussusception of ileum through a persistent omphalomesenteric duct is a dangerous complication, mor-

tality in recently reported cases is considerably less than that previously recorded.

SUMMARY

1. Forty-six symptomatic cases of incomplete omphalomesenteric duct obliteration are reported. The malformation consisted of a persistent omphalomesenteric duct in 10 cases, a diverticulum attached to the umbilicus by a fibrous cord in 5, and a Meckel's diverticulum in 31.

2. The sex, race, and age incidence are discussed. Although Meckel's diverticulum appears to occur with equal frequency in both sexes, there is a significant male preponderance in symptomatic cases, especially in those with gastric mucosa in the diverticulum. The ages of the patients varied widely. However, 78 per cent of the patients were 15 years of age or younger and one-third were in their first year of life.

3. Intestinal obstruction, abdominal pain, and melena with anemia were the most frequently encountered major symptoms.

4. Intussusception of ileum onto the abdominal wall through a persistent omphalomesenteric duct was encountered in 5 cases. In 1 case, the prolapse occurred on top of an omphalocele. Four of the 5 infants survived.

5. A diverticulum, attached to the umbilicus by a fibrous cord, was the cause of intestinal obstruction in 4 cases and the site of an acute diverticulitis in 1 case. In 1 of the cases, the diverticulum arose from the side of the appendix. All 5 patients recovered.

6. A Meckel's diverticulum was the site of pathologic change in the form of diverticulitis in 12 cases, with melena and anemia in 10 cases and by acting as the leading point for an intussusception in 6 cases. A perforated peptic ulcer was found in 3 of these cases. All 28 patients recovered.

7. The possibility that a Meckel's diverticulum with a more firm or bulky type of heterotopic tissue, such as gastric or pancreatic, may be more likely to act as the leading point for an intussusception is discussed.

8. In 3 cases, adherence of a Meckel's diverticulum to an adjacent structure, other than the umbilicus, formed a ring for an internal hernia. Gangrene of the incarcerated loop of intestine occurred in 2 of the 3 patients. All 3 patients died. Only 1 of them was operated upon. The serious character of this type of obstruction produced by a Meckel's diverticulum is emphasized.

9. Forty-four of the patients were operated upon and all but 3 (7 per cent) recovered. Two of the 3 deaths were due principally to additional congenital abnormalities.

REFERENCES

1. Aitken, J. Remnants of vitello-intestinal duct; analysis of 88 cases. Arch. Dis. Childh., 1953, 28: 1.
2. Allen, M. S., and Fitchett, C. W. Omphalocele with a patent everted omphalomesenteric duct. Surgery, 1952, 32: 715.
3. Arnheim, E. E. Surgical complications of congenital anomalies of the umbilical region. Surg. Gyn. Obst., 1950, 91: 71.
4. Bronaugh, W. Herniation and extrophy of the ileum in the newborn incidental to adherent Meckel's diverticulum in the umbilical area. West Virginia M. J., 1947, 43: 126.
5. Brown, A. G., and Cain, F. G. Evagination of ileum through patent omphalomesenteric duct. Am. J. Surg., 1950, 79: 339.
6. Gandry, D. Anomalies congenitales de l'ombilic. Union méd. Canada, 1952, 81: 31.
7. Gross, R. E. The Surgery of Infancy and Childhood. Philadelphia: W. B. Saunders Co., 1953.
8. Hadley, M. N., and Cogswell, H. D. Unusual origin of Meckel's diverticulum from the base of the appendix. J. Am. M. Ass., 1936, 106: 537.
9. Hagemeyer, F. W. Inversion and Duenndarmprolapse bei offenem Ductus omphalomesentericus und gleichzeitiges Vorkommen eines Nabelsnurbruches. Zbl. Chir., 1954, 79: 1405.
10. Kirtland, H. B. Patent omphalomesenteric duct. Arch. Surg., 1951, 63: 706.
11. Kittle, C. F., Jenkins, H. P., and Dragstedt, L. R. Patent omphalomesenteric duct and its relation to the diverticulum of Meckel. Arch. Surg., 1947, 54: 10.
12. Lowman, R. M., Waters, L. L., and Stanley, H. W. The roentgen aspects of congenital anomalies in the umbilical region. Am. J. Roentg., 1953, 70: 883.
13. Michel, M. L., Field, R. J., and Ogden, W. W. Meckel's diverticulum. Ann. Surg., 1955, 141: 819.
14. Migliaccio, A. V., and Begg, C. Meckel's diverticulum. Am. J. Surg., 1948, 76: 188.
15. Moore, T. C., and Shumacker, H. B., Jr. Intussusception of ileum through persistent omphalomesenteric duct. Surgery, 1952, 31: 278.
16. Singleton, A. O., Jr., and King, W. B. Persistent vitelline duct continuous with the appendix. Surgery, 1951, 29: 278.
17. Soderlund, S. Meckel's diverticulum in children; a report of 115 cases. Acta chir. scand., 1956, 110: 261.

AN EXPERIMENTAL STUDY RELATING FABRIC TYPES WITH SEVERITY OF BURNS

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THERMAL INJURY assumed paramount importance to military and civil defense agencies alike during World War II. Two types of burns were commonly encountered: (1) burns in which the individual's clothing is heated to the ignition or melting point, and (2) flash burns, in which the individual is exposed to a source of intense radiant energy for brief periods of time.

Eckert and Mader reported on flash burn casualties at Pearl Harbor, and noted that "only exposed surfaces were burned, even an undershirt or shorts appeared sufficient to prevent areas covered from being burned." Furthermore, with the advent of atomic bomb explosions at Hiroshima and Nagasaki the tremendous number of burn casualties again focused attention on the flash burn. LeRoy estimated that 64 to 85 per cent suffered from radiation injury. Parsons pointed out that the effects of blast and heat extended over a wider area than did those of radiation, and individuals as far as 2.5 miles from ground zero received burns severe enough to require treatment.

However, the term "flash burn" does not describe a single entity, and it is dangerous to assume that the characteristics of all flash burns are similar. First, the spectral distribution of the radiant energy applied is significant. Berkely and Davis demonstrated that the 50 per cent effective dose of radiant energy required for cutaneous injury is significantly greater for infrared radiation than for visible or unmodified radiation from a carbon arc source. It is likely that ultraviolet radiation will also have distinct characteristics. Obviously, the spectral distribution of radiant energy emanating from an atomic explosion is likely to differ from that of a flame or gasoline explosion, and drawing of close analogies should be done with caution.

Furthermore, the time and intensity of applied thermal energy is related to the severity of resulting burns. It was noted by Moritz and Henriques (7) that an inverse relationship existed between the level of temperature and the time of its application. This observation was substantiated by the work of Perkins and associates utilizing brief pulses of high intensity radiant energy.

The technique employed in the present study attempted to simulate the flash burn commonly encountered in gasoline or industrial explosions. It differs in both spectral distribution and time and intensity relationships from atomic or thermonuclear explosions. While general properties of the fabrics may also hold true with the latter, at present this work should not be considered to answer all the problems encountered in this highly specialized type of explosion.

Burns in which clothing is heated to ignition or the melting point were common enough in war as well as in civilian and industrial experience. For example, these burns were seen in large scale in the recent disasters in Hartford and Boston.

REVIEW OF THE LITERATURE

It is obvious that clothing may either contribute to the severity of the burn by supporting combustion, or it may, by virtue of its weave, color, or fabric type offer some

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TABLE I.—DATA ON FLASH BURNS

Fabric No.	*Description*	*Initial burn*	*Course*	*Wt. change*	*Average healing time, days*	*Path. grade*
1	Cloth, cotton twill	1″ disk, discolored, fabric charred greater than 1″ diam.	9 day slough ++ to +++ with hemorrhagic edges	None	46	3 to 4
2	Cloth, cotton basket	1″ diam. discolored and raised	6 day slough ++ to +++	None	31	3
3	Cloth, cotton sateen	1″ disk	13 to 15 day slough + to ++	Slt. gain	35	3
4	Cloth, cotton twill, process I treated	1″ raised disk	9 to 13 day slough ++ to +++ large hemorrhagic extension of burned area	Slt. gain	32	3
5	Cloth, cotton twill, process II treated	1″ raised white disk	13 to 19 day slough + to ++	Slt. gain	35	3
6	Cloth, cotton, Oxford cloth	1″ diam. discolored and raised	7 day slough ++ to +++	None	44	3
7	Spun nylon and cotton mock leno, process I treated	1″ white coagulum disk	Slough 9 to 15 days + to ++	Slt. gain	24	3
8	Spun nylon and cotton mock leno process II treated	1″ raised disk with hemorrhagic margin	Slough 13 days + to ++	Slt. gain	33	3
9	Cotton twill, untreated	1″ diam. raised and discolored	13 to 15 day slough + to ++	Slt. gain	29	3
10	Rayon, viscose untreated	1″ raised and discolored with marginal petechiae	9 to 13 day slough + to ++	Slt. gain	28	3
11	Viscose rayon-nylon	1″ diam. melted to skin	9 to 13 day slough + to ++	Slt. gain	27	3
12	Cloth, nylon dobby	1″ diam. discolored raised melted to skin	6 day slough ++	Slt. gain	25	3
13	Nylon, 5.3 oz.	1″ diam., discolored raised, melted into skin	7 day slough ++	Slt. gain	26	3
14	Nylon fabric, 3.3 ounces	1″ diam., melted into skin	9 day slough ++ to +++	Slt. gain	41	4
15	Wool-rayon jacket liner, fuzzy side out	Almost no burn visible initially	9 day slough + to ++	None	27	3 to 4
16	Wool pile	No burns in 6 rats	—	—	—	—
17	Wool serge, 18 oz.	Slightly raised area	6 to 9 day slough + to ++	Slt. gain	29	3
18	Wool-rayon jacket liner, smooth side out	1″ diam., disk with central petechiae	9 to 13 day slough + to ++	Slt. gain	31	3
19	Cloth, wool, gabardine	1″ diam., white with marginal hemorrhage	13 to 15 days + to ++	Slt. gain	31, unhealed	2
20	Wool, knitted	1″ diam., with central petechiae	9 day slough + to ++	Slt. gain	18	3

TABLE I.—DATA ON FLASH BURNS—Continued

Fabric No.	*Description*	*Initial burn*	*Course*	*Wt. change*	*Average healing time, days*	*Path. grade*
21	Acetate rayon, blouse	1″ diam., charred raised adherent to skin	6 days slough + to ++	Slt. gain	30	4
22	White silk	1″ diam., white coagulum fabric adherent to skin	Sloughing at 13 days	Slt. gain	31	3
23	Egyptian cotton basket weave, untreated, sage green, 5.57 oz.	1″ diam., pale soft, depressed	10 day slough ++	None	35	3
24	Egyptian cotton basket weave, untreated, bleached, 5.57 oz.	1″ diam., flat soft pale	11 days slough + to ++	Slt. gain	24	2
25	Egyptian cotton plain weave, untreated, sage green, 5.12 oz.	1″ diam., firm depressed	8 day slough ++ to +++	Slt. gain	40	3
26	Egyptian cotton plain weave, untreated, bleached, 5.12 oz.	1″ diam., thickened raised	10 day slough + to ++	Slt. gain	43	2
27	Dacron	1″ diam., soft flat cloth adheres	8 day slough ++	Slt. gain	31	3
28	Aluminized airplane fabric	1″ diam., yellowed and raised	11 day slough++	None	34	3
29	Cotton-dacron	1″ diam., flat firm adheres to skin	7 day slough + to ++	None	29	3
30	Cotton-nylon mock leno anti-G suit	1″ diam., pale green flat	10 day slough + to ++	Slt. gain	28	2
31	Flightex cotton with flame retardant	1″ diam., soft pale raised	8 day slough + to ++	Slt. gain	30	2
32	Skinner jacket liner, nylon facing wool base	Small singed area	10 day slough +	Slt. gain	24	1
33	Aluminized asbestos cloth	Pale, flat, charred 1″ diam.	Slough 7 days + to ++	None	32	1
Control no fabric	No fabric	1″ diam., depressed, soft	Slough 11 days ++	Slt. gain	31	3

degree of protection. A review of the literature showed that investigation of the protective effects of fabric is limited. Morton and associates using a carbon arc searchlight as a source of intense radiant energy found that dark clothing, with less radiant energy reflectance afforded less protection than white clothing. This confirmed observations from the Japanese atomic explosions. They also noted that "all materials gave some protection, although this was not marked in many instances," and "color is of greater importance than is weave, weight of material, or light transmission." Mixter and Pearse showed that multiple layers of fabric offered more protection than did single layers.

Experimental studies of the nature of flash burns were carried out by Moritz (6), Moritz and Henriques (7), Morton and associates (9), and Pearse and associates. They agreed

TABLE II.—DATA ON NONFLASH BURNS

Fabric No.	*Description*	*Initial burn*	*Course*	*Wt. change*	*Average healing time, days*	*Path. grade*
1	Cloth, cotton twill	Soft, thickened	¾ by ¾″ burn + to ++, 8 day slough	Slt. gain	23	3
2	Cloth, cotton basket	Soft, dark, raised	¾ by ¾″ burn ++, 11 day slough	Slt. gain	26	1 to 2
3	Cloth, cotton sateen	Thick, raised, white	¼ by ⅛″ burn ++, 18 day slough	—	Sacrificed at 25, unhealed	3
4	Cloth, cotton twill, process I treated	Chars and goes out; no burns in 6 rats	—	—	—	—
5	Cloth, cotton twill, process II treated	Chars and goes out; no burns in 6 rats	—	—	—	—
6	Cloth, cotton, Oxford cloth	Pale depressed soft	1¼ by ¾″ burn ++, 11 day slough	Slt. gain	29	2 to 3
7	Spun nylon cotton mock leno, process I treated	No burns in 6 rats	—	—	—	—
8	Spun nylon and cotton mock leno, process II treated	No burns in 6 rats	—	—	—	—
9	Cotton twill, untreated flying suit (4, 5)	Soft, flat	⅓ by 1⅓″ burn sloughing 18 days	—	Sacrificed at 25, unhealed	2
10	Rayon (viscose untreated)	Pale, soft flat	8 day slough, 1 by ¼″ burn, +	Slt. gain	16	1
11	Viscose rayon-nylon	Burns poorly; no burns, 3 rats, tiny superficial burns in 3 rats	—	—	19 (3 rats)	—
12	Cloth, nylon dobby old flying suit	1 pin point burn in 1 of 6 rats	—	—	—	—
13	Nylon fabric, 5.3 ounce	Melts, does not ignite. No burns in 6 rats	—	—	—	—
14	Nylon fabric, 3.3 ounce	Melts, does not burn. No burns 5 rats, pin point burn in 1 rat	—	—	15 (1 rat)	—
15	Wool-rayon jacket liner, fuzzy side out	No burn 3 rats, singes in 3 rats	Only 1 clinical burn, +	Slt. gain	22 (1 rat)	2
16	Wool pile	Chars, goes out. No burn 5 rats, singe 1 rat	—	—	25 (1 rat)	1
17	18 oz. wool serge	No burns 4 rats, singes 2 rats	—	—	21 (2 rats)	—
18	Wool-rayon jacket liner, smooth side out	Not tested	—	—	—	—
19	Cloth, wool gabardine	No burns 5 rats, small singe 1 rat. Ignites, melts, goes out	—	—	—	—
20	Wool, knitted	No burns 5 rats, superficial burn 1 rat	—	—	21 (1 rat)	—

TABLE II.—DATA ON NONFLASH BURNS—Continued

Fabric No.	*Description*	*Initial burn*	*Course*	*Wt. change*	*Average healing time, days*	*Path. grade*
21	Acetate rayon, blouse	No burn 3 rats, pale flat, soft in 3 rats	8 day slough, ¼ by ¾″ burn, + to ++	Slt. gain	26	2 to 3
22	Silk, white	Melts, does not ignite. No burns 5 rats, singe 1 rat	—	—	15 (1 rat)	—
23	Egyptian cotton basket weave, untreated, sage green, 5.57 oz.	Soft, flat, dark	¾ by ¼″ burn, +, 11 day slough	Slt. gain	19	2
24	Egyptian cotton basket weave, untreated, bleached, 5.57 oz.	Soft, pale, flat	1 by ¼″ burn, +, superficial 8 day slough	Slt. gain	14	1
25	Egyptian cotton plain weave, untreated, sage green, 5.12 oz.	Pale, soft, raised	¾ by ¼″ burn, +, 8 day slough	Slt. gain	20	3
26	Egyptian cotton plain weave, untreated, bleached, 5.12 oz.	Pale, soft	½ by ½″ burn, +, 8 day slough	None	14	1
27	Dacron	No burn 6 rats	—	—	—	—
28	Aluminized airplane fabric	No burns	—	—	—	—
29	Cotton-dacron	Soft, flat, dark	½ by ½″ burn, + to ++, 8-11 day slough	Slt. gain	29	1
30	Cotton-nylon mock leno, anti-G suit	Pale, soft, flat	½ by ¾″ burns, +	Slt. gain	19	2
31	Flightex cotton, flame retardant treated	No burns in 6 rats	—	—	—	—
32	Skinner jacket liner, nylon taffeta facing, wool base	No burn 2 rats, slt. burn 4 rats	¼ by ¼″ burn, +, 8 day slough	Slt. gain	18 (4 rats)	1 to 2
33	Aluminized asbestos cloth	No burns in 4 experiments	—	—	—	—

that high intensity thermal radiation of brief duration resulted in a coagulative type of necrosis with sequestration of dead tissue rather than autolysis. Low intensity, long duration burns are characterized by autolysis, noncoagulative type necrosis, and organization. Accordingly, any method seeking to produce flash burns experimentally must duplicate the former pathologic picture.

The following experiment was designed to test the protective effects, if any, of 33 different fabrics of varying weights, weaves, colors, and flame retardant treatments against both flash and nonflash burns.

METHODS

Sprague-Dawley rats were procured, and after the usual quarantine period to assure their health, they were clipped with surgical shears to remove the hair in the area of the thorax and abdomen. Twenty-four hours later the rats were anesthetized with pentobarbital sodium and weighed. Bands of the fabrics were made to cover the animals' abdomens and were fitted snugly, then the cloth was stapled together at the top of the back. Each band of fabric was composed of 2 strips of different material joined at the midventral abdominal area. The animals were exposed

to burning on each side and by using a different fabric on either side it was possible to observe the effects of injury in twice as many animals.

In one series of experiments, the flash burn group, the animals were exposed to circular areas, 1 inch in diameter, on either side of the abdomen (Table I). This was done by preparing an asbestos board with a circular opening 1 inch in diameter. The animals were held against one side of this board exposing the area to be burned along with its covering of the various materials in question. The source of heat for this series was a Meker burner using natural gas. It was determined by thermopile measurement that the apparatus delivered a temperature of 2200 degrees F. at this point. The rats were exposed to the flame for 3 seconds. Each fabric was tested in this manner on 6 animals.

In the other group of experiments, the nonflash burns, the fabric was heated to ignition (Table II). The preparation of the animals was the same as for the flash burns except that on each side of the animal a standard wick of the experimental fabric was prepared. This wick was then ignited, away from the animal's body, and allowed to burn down to the area in contact with the rat's skin, thus the severity of the lesions was controlled by the inherent effects of the burning of each individual fabric.

The data in each series were recorded in the same manner. Immediately after burning, the exposed area was examined and an estimate made of the severity of the lesion. The wounds were then examined at regular intervals throughout the healing process and measurements of the size of the burn were taken along with other clinical data such as appearance of sloughing and presence of surrounding hemorrhages in the skin. Further records of the progress of the healing were made by color photography of a representative animal from each group at 24 hours, 1, 2, and 3 weeks after burning. Each animal was weighed several times during the healing period, and this weight was compared with the initial weight. One member of each series of 6 rats was sacrificed 24 hours after burning and the affected areas examined microscopically in an endeavor to determine accurately the depth and extent of the lesion. Another of each series was sacrificed during the course of healing, 15 to 18 days after burning, to estimate further the degree of burning and to determine the rate of healing. The remainder of the animals were observed until healed and average healing times were determined for the various fabrics.

RESULTS

One hundred and ninety-five experiments involving nonflash burns were performed. Fabrics composed entirely of wool, asbestos, nylon, dacron, silk, or flame retardant treated cotton did not support combustion. These fabrics charred or melted while the ignition flame was applied but ceased to burn before the flame reached the body of the animal. No significant burn was obtained with these fabrics.

Combinations of cotton and dacron or cotton and nylon ignited readily but burned sluggishly. They produced burns of slight to moderate severity which healed rapidly. Fabrics of this type treated with antiflame agents did not ignite and produced no burns. Acetate rayon and viscose rayon gave burns of moderate severity. These fabrics ignited readily but burned poorly in the oxygen-poor region adjacent to the body of the animals.

Untreated cotton materials were ignited with ease and burned vigorously, often continuing to blaze until the greater portion of the cloth sample was reduced to ash. Wide deep burns were produced and healed rather slowly. Cotton sateen and flying suit cotton twill gave burns which were still open and unhealed when the animals were sacrificed after 4 weeks.

The severity of burns from the same material varied with the looseness of the garment on the animals. The most extensive burns seen were in animals wrapped loosely

enough to permit free circulation of air under the burning cloth.

Flash burns were studied in 238 experiments. Burns were obtained with all fabrics except wool pile. Thick materials, such as wool serge, pile, gabardine, and knit, 5.3 ounce nylon, and nylon dobby, or fabrics treated with flame retardant process I gave the least severe burns which healed rapidly. Thin fabrics, such as 3.3 ounce nylon gave severe burns which healed slowly. Pure cotton fabrics in general produced the most severe burns, with the involved area often extending beyond the area to which the flame was initially applied. Healing time was often greater than in 18 control animals burned without a cloth covering. Flame retardant process II treatment gave no apparent protection against flash burns, but process I treatment reduced the healing time for cotton and nylon-cotton combinations.

Color appeared to be more significant in flash burns than in burns from cloth heated to ignition. Light colors offered more protection than dark.

PATHOLOGY

Gross pathologic observations were made immediately after burning, daily for the first 7 days, and every second day thereafter. The appearance, consistency, and size of the resulting lesions were recorded, in order to correlate gross appearance with healing time and microscopic appearance.

Each animal was examined at frequent intervals, and the burns classified as +, + +, or + + + on the basis of extent of lesion, presence of hemorrhagic margins, and rate of sloughing.

One animal in each group of 6 was sacrificed at 24 hours, and another at 15 to 18 days for the purpose of studying depth and histologic characteristics of the resulting burns. The lesions were graded on this basis as follows:

1. Superficial damage only, with local autolysis. This group of cases consists of thickening of the stratified squamous epithelium with occasional small increases in the interstitial spaces. This would correspond with a first degree burn by clinical classification.

2. Coagulative necrosis and sequestration of dead tissue extending to less than half the thickness of the corium. Cases included in this group may or may not have some of the stratified squamous epithelium destroyed. Spaces may sometimes separate the stratified squamous epithelium from the dermal fiber. The collagen bundles of the superficial portion of the corium have undergone coagulation necrosis. This corresponds to a second degree burn.

3. Coagulative necrosis which extends to the full thickness of the corium, but fails to involve subcutaneous tissues. There is little or no injury to the cutaneous muscle. Cases of this magnitude of injury do not often have any stratified squamous epithelial covering over the center of the lesion. This corresponds to third degree injury.

4. Severe coagulative necrosis involving not only full thickness of corium, but subcutaneous fat and muscle as well. The cutaneous muscle exhibits varying degrees of injury. Deep craters often are present over the central portion of the lesion. The margins of the lesion may be heavily infiltrated with leucocytes. The heavy infiltrates observed in this group are considered to represent secondary bacterial infections.

The histologic grading was carried out by code so that the pathologist had no knowledge of the fabric tested or the gross extent of burn. Upon completion of the grading, an attempt was made to correlate the histologic picture with gross appearance and healing time. Admittedly, exact correlations cannot be expected for both gross and microscopic grading scales are relatively crude; and depth and extent of burn may vary independently. Perhaps the largest source of error is possible in histologic grading where judgment depends entirely upon whether or not the specimen is entirely typical of the majority of the burned area, i.e., a grade 4 burn may be misgraded by inadvertently selecting a less severely involved area near the margin. On

this basis then, the following conclusions are valid: (1) For burns of equal histologic depth, in this series, nonflash burns healed approximately 25 per cent faster than flash burns. This probably reflects the fact that the former tend to involve less total area. (2) There is a rough correlation of gross appearance and healing time within a single histologic grade. For example, in 20 grade 3 flash burns, the mean healing times for burns grossly rated + to ++ were 29 days, ++ were 32.4 days, and ++ to +++ were 36.7 days. (3) There was no histologic picture which could be said to be typical of any fabric tested. That is, there was no microscopic evidence that a burn involving nylon, for example, differed histologically in any specific way from any other fabric tested. (4) A review of histologic sections fails to reveal any significant morphologic difference between burns of flash and nonflash origin utilizing this technique.

DISCUSSION

The technique employed for the production of flash burns proved satisfactorily to produce the gross and microscopic pictures of this type of thermal injury. In 198 experiments standard burns 1 inch in diameter resulted. It was found that weight of material, fabric tested, color, weave, and flame retardant treatment, if any, all played important roles and modified the resulting burns as reflected in the extent and depth of burn and healing time. In each series, the burns were found to be extremely reproducible.

Based on this experimental sequence and tabulation of histologic, gross, and clinical data, a number of factors emerged. In our experience, the weight, i.e., thickness, of the cloth seemed the most important factor with heavier cloth giving more protection than light weight materials.

Second in importance was the actual fabric used, and this seemed to depend on its ability to conduct heat. For example, if arranged in order of this decreasing ability to protect against flash burns, fabrics would read: wool, heavy synthetic fabrics, such as nylon and dacron, heavy synthetic-cotton combinations, treated cotton, light weight synthetics, and untreated cotton. It should be noted that very light weight nylon and untreated cottons may give less protection than no fabrics at all, as shown by the very long healing time involved.

Of next importance was the color of the fabric. This work corroborated previous observations that dark colored fabrics offered less protection than light or bleached materials. This fact is attributed to the low radiant energy reflectance pertaining to the darker fabrics.

Cotton fabrics were found to protect against flash burns when treated with process I flame retardant. Process II treatment was less effective but may be better than untreated cloth alone. For nylon-cotton fabrics, process II was no better than untreated materials but process I was consistently found to offer protection. This was attributed to the ability of this flame retardant to limit the spread of the heat and charring of the fabrics. In burns larger than the 1 inch diameter standard, it was felt that spreading of the heat and charring were at least partially responsible.

The identical set of 33 fabrics was also tested by heating a wick of material to its ignition or melting point and observing the clinical burns, if any, which resulted. The pure synthetic fabrics, i.e., the nylon and dacron, with the exception of acetate and viscose rayon, failed to support combustion. The fabrics simply melted and no clinical burns resulted. Wool and flame retardant treated cottons likewise failed to produce burns. When cotton was combined with synthetics, as in cotton-nylon mock leno and cotton-dacron combinations, burns resulted. However, these burns were never extensive and healed promptly. Process I and II flame retardants protected against clinical burns when applied to cotton-synthetic combinations.

In direct contrast to the results with synthetic fabrics is the observation that every

one of the untreated cottons supported combustion and produced clinical burns. It was further noted that when loose fitting material was ignited, the resulting burn was far more severe than when the same material was tight fitting. Mixter and Pearse made similar observations with loose fitting garments subjected to flash burns.

The rather surprising result of this study was the excellent over-all protection offered by synthetic nylon or dacron combined with cotton to get the best features of each material.

The clinical importance of such observations is shown in Colebrook's report. He analyzed the role of clothing in burn accidents. In a study of 92 cases in which clothing was ignited the breakdown of fabrics implicated is: cotton 61, viscose rayon 19, acetate rayon 2, cotton and wool 3, cotton and viscose rayon 2, viscose and acetate rayon 1, and wool 4. In this group, all cellulose fabrics were indicted, with cottons by far the commonest offenders, especially "raised cotton," or imitation angora fabric. Of the 4 patients who were wearing woolen materials, these people were, without exception, epileptics or aged people who had fallen directly into an open fire. The low incidence of burns with new synthetic fabrics such as nylon and dacron is due in part to their failure to support combustion, but also reflects the fact that they were not as commonly worn at the time of the study as cottons and woolens. This survey constitutes a well founded plea for treatment of cellulose fabrics with flame retardants.

SUMMARY

1. A technique is described for bio-assay of the protection offered by 33 different common fabrics against the type of thermal injury encountered when clothing is heated to the ignition or melting point, or exposed to one type of flash burn.

2. The gross and microscopic pathology resulting from these types of thermal injury is reported.

3. In order of decreasing importance, protection against flash burns was found to lie in: weight or thickness of material used, with heavy materials offering best protection; ability to conduct heat, an inherent quality of the material; color of fabric, with dark colors protecting less than light; process I flame retardant treatments.

4. When the same fabrics were tested with nonflash type burns the synthetics such as nylon and dacron (with the exception of acetate and viscose rayon) as well as wool and flame retardant treated cottons failed to support combustion and produced no burns. Cotton-synthetic combinations burned sluggishly, but flame retardant treatment prevented this damage. Every sample of untreated cotton yielded clinical burns.

5. Loose fitting garments are far more dangerous than tight when ignited, and resulting burns are many times as severe.

6. These experimental results agree closely with similar clinical studies in a large emergency hospital.

REFERENCES

1. Berkely, K. M., and Davis, T. P. Studies on flash burns; the influence of wave length on the production of cutaneous burns. AE Project, UR283, 1953.
2. Colebrook, L. A suggested national plan to reduce burning accidents. Lancet, Lond., 1951, 261: 579.
3. Eckert, G., and Mader, J. W. The solace in action. U. S. Nav. M. Bull., 1942, 40: 552.
4. LeRoy, G. The medical sequelae of the atomic bomb explosion. J. Am. M. Ass., 1947, 134: 1143.
5. Mixter, G., and Pearse, H. E. Studies on flash burns; the protection afforded by 2, 4, and 6 layer fabric combinations. AE Project, V2-261, 1953.
6. Moritz, A. R. Studies of thermal injury—III, the pathology and pathogenesis of cutaneous burns; an experimental study. Am. J. Path., 1947, 23: 915.
7. Moritz, A. R., and Henriques, F. C. Studies of thermal injury—II, the relative importance of time and surface temperature in the causation of cutaneous burns. Am. J. Path., 1947, 23: 695.
8. Morton, J. H., Kingsley, H., and Pearse, H. E. Studies on flash burns: protective effects of certain fabrics. Surg. Gyn. Obst., 1952, 94: 497.
9. Idem. Studies on flash burns: threshold burns. Surg. Gyn. Obst., 1952, 94: 317-322.
10. Parsons, R. P. Trauma resulting from atomic explosion. Am. J. Surg., 1948, 76: 559.
11. Pearse, H. E., Payne, J. T., and Hogg, L. The experimental study of flash burns. Ann Surg., 1949, 130: 774.
12. Perkins, J. B., Pearse, H. E., and Kingsley, H. D. Study on flash burns; the relation of the time and intensity of applied thermal energy to the severity of burns. AE Project UR217, 1952.

THE EFFECT OF LARGE CALIBER SPLINTS ON URETERAL HEALING

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WHEN A URETER is dilated or a splint is placed therein there appears to be a marked tendency to use an instrument of the largest diameter which can be introduced into the lumen. This is a logical maneuver, as it would seem that the lumen requiring the splint would close down as the scar tissue becomes more mature. It is sometimes a painful experience to accomplish a very satisfactory ureteral repair only to have the symptoms return in several months and a very tight stricture form at or near a regenerated area. As our experimental work on the fate of the kidney and the functional result of the regenerated ureteral area was continued, this problem presented itself very clearly. Our experimental animals were found to have impassable ureteral strictures at the distal end of the splint when a splint of large size was used. When the probable cause of the stricture was ascertained, smaller splints were employed with no resultant stricture. The question then arose: Could the use of large caliber splints be a possible cause of clinical postoperative strictures? Stricture formation has apparently been a complication, as many surgeons attempt to put the splint into the bladder or to extend it as far into the ureter distally as possible. We have attempted to answer these questions in the laboratory.

MATERIAL AND METHOD

Fourteen dogs were operated upon in the usual manner of our previous ureteral experiments. Under pentobarbital sodium anesthesia a left flank incision was made under the twelfth rib which was developed to Gerota's fascia where the kidney was exposed together with 6 centimeters of the ureter. The ureter was completely excised for 3 centimeters except for a very small remaining strip (1 to 2 mm.) containing all the components of the wall. This excised area started 1.0 centimeter distal to the ureteropelvic junction, and a No. 8 French Davol rubber T drain was introduced as a combined nephrostomy tube and ureteral splint (Fig. 1). Latex rubber was used because of its property of great softness and pliability and thus any trauma to the ureter was reduced to a minimum; a No. 8 French T drain is the smallest T drain made, but even this is too large for the diameter of the ureteral lumen in the average large dog. It was necessary, therefore, to dilate the distal ureter below the excised area which was done with a No. 10 French Garceau ureteral catheter. When the dilatation was done slowly, a particular "give" to the tissues was noticed which was roughly similar to the sensation obtained when a small metal ribbon is stretched just beyond its limit of elasticity. The T drain was left in situ for 6 weeks which had been established as the time interval for regeneration of all of the components of the ureteral wall. The tube was then withdrawn, and the animal was reoperated upon 10 weeks following its removal.

The reoperation followed the previous incision when the ureter was exposed distally, and catheters of various sizes were then introduced proximally together with the injection of various fluids to attempt passage to the kidney. The kidney and 8 centimeters of the attached ureter were removed following which catheters, filiforms, and fluids were injected retrograde.

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A second group of 10 dogs were operated upon in the same manner as previously described with this exception: a straight polyethylene plastic tube was used for the splint and nephrostomy tube, the size of which was No. 3 to No. 5 French depending upon which one could be passed down the ureter without pressure or dilatation. This drain was removed and the dogs were reoperated upon as in the preceding group. The site of the regenerated area was examined and probed with No. 5 French catheters. Sections were taken both through the normal and the regenerated segments. These were prepared with paraffin technique. Both preoperative and postoperative intravenous urograms were taken by injecting 20 cubic centimeters of 70 per cent urokon sodium for maximum concentration. The purpose of this experiment was to see: (1) if fibrosis occurred at the end of the ureteral splint; (2) if it occurred in the same amount with a small as with a large splint which overdistended the ureteral lumen.

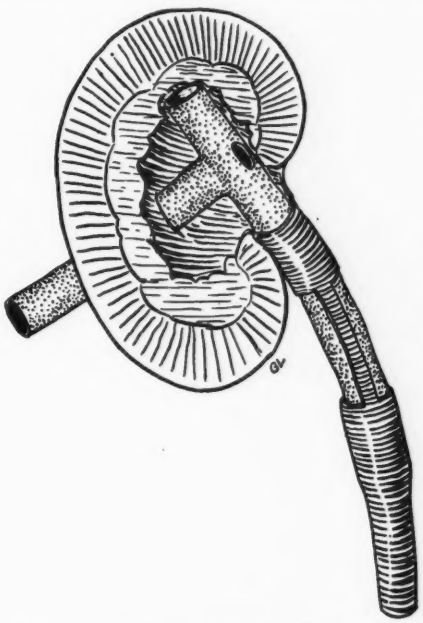

FIG. 1. Sketch of canine kidney with T tube in situ. Note the overdistention of the tube in the proximal ureter.

RESULTS

In this experiment, conditions simulating clinical problems were kept as closely allied as possible, as in these various groups the behavior of the kidney was of prime interest.

In the first group of animals in which the oversized rubber T tube was used, the perirenal and periureteral fibroses were very dense, usually extending 2 to 3 centimeters below the excised regenerated area. The ureter below the inflammatory area appeared grossly normal in all respects. The regenerated area was markedly dilated with increased fibrosis of the wall which fused tightly with the surrounding scar tissue, and it was impossible to pass any size of filiform bougie through the stricture which was located in all cases just beyond the distal end of the regenerated segment. This area corresponded with the location of the end of the T tube splint. In 70 per cent of the animals, water could not be forced through this area with a syringe placed either proximally or distally, and the kidney showed a very large pyonephrosis, the cavity of which was filled with thick, purulent urine, a very thin parenchyma, and finally the organ was seen to be nonfunctioning on intravenous urography. Microscopically, the uninvolved distal ureter showed no changes from the normal while the regenerated area was heavily infiltrated with polymorphonuclear leucocytes and fibrous tissue. The same regenerated elements of mucosa and muscularis layers were seen in the same manner as previously observed in our first report on ureteral regeneration and also recorded by authors before and since. The area around the stricture showed a thin underdeveloped muscularis with a marked increase in the fibrous tissue and inflammatory elements. The mucosa was low, thinning out to become nearly absent with the progressive decrease of the diameter of the lumen (Fig. 2).

The second group of animals consisted of those in which the splint was readily accommodated by the ureteral lumen, and in which great care was taken at the time of

FIG. 2.

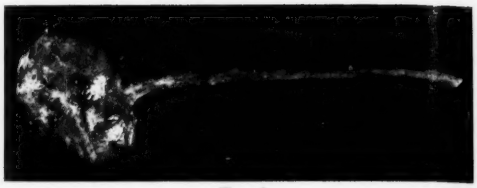

FIG. 3.

FIG. 2. Photomicrograph showing increased fibrous tissue and impassable stricture 12 weeks after removal of an oversized ureteral splint.

FIG. 3. Gross specimen of a canine kidney and ureter 12 weeks following regeneration over a small ureteral splint.

surgery to produce no stretching or trauma of the wall. Gross observation of this group showed a normal appearing ureter distal to a regenerated area with the exception of 2 cases in which the splint (No. 6 French) of the type used prior to the small (No. 3 to 5 French) splints was snug in the lumen. These 2 animals showed mild edema only, which was observed within 2 weeks of the removal of the splint. The regenerated area had a lumen of roughly 2 times the diameter of the normal ureter and the wall showed some increased fibrosis, but the perirenal and periureteral fibrosis seen in the preceding group was absent. Strong but thin strands of fibrous tissue were present binding the ureter firmly to the opposing lower pole of the kidney and extending up to the pelvis, but these were readily dissected with sharp and blunt dissection, and did not hamper ureteral motility. The kidney was of normal size and gross appearance, being bound to the wall with only patchy areas of fibrosis especially at the lateral surface around the area of the nephrostomy tube (Fig. 3). The surfaces made by cutting showed normal appearing parenchyma with no appreciable hydronephrosis, while the distal junction of the regenerated area and normal ureter admitted a No. 5 French ureteral catheter without difficulty and water passed freely both proximally and distally when introduced with a syringe. Microscopically, no changes were noted in the normal ureter even though the splint was left in situ for 6 weeks. The regenerated area showed fewer fibrous and inflammatory elements with the familiar picture of the muscularis and mucosal changes.

DISCUSSION

A factor of prime importance, both experimentally and clinically, was the large caliber of the lumen of the regenerated area which roughly averaged 2 times the diameter of the splint. The most noticeable pathologic result from use of large or oversized splints was the markedly fibrotic stricture at the distal end probably from overstretching which caused some surgeons to carry the splint into the bladder in order to avoid stricture formation. The pathogenesis appears to be stricture formation, stasis, infection (pyelonephritis and ureteritis), and finally periureteral and perinephric fibrosis.

This concept is not new and was covered in detail in the comprehensive work of Greene on overdilatation of the ureter; however, fibrous stricture caused by the oversized splint was a phenomenon which was not expected to be observed. It was only after operating upon a series of 12 dogs that the probable etiology was suspected and remedied. It was further noted that wound infection was minimal and seen only in 5 per cent of the cases. In this series it was not a factor in postoperative management, nor in the production of the perinephric fibrosis.

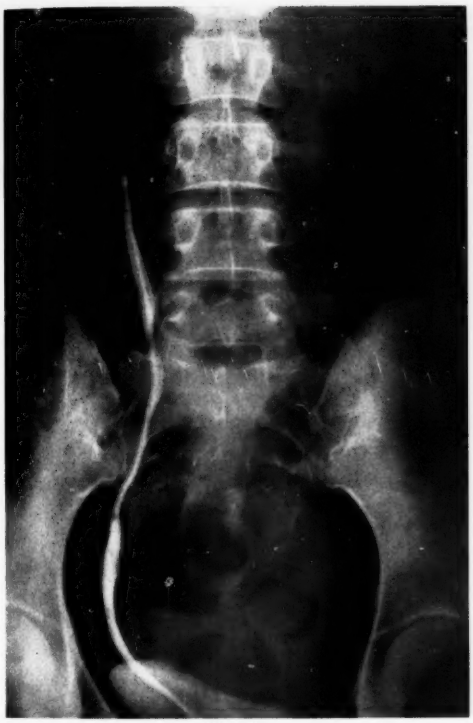

FIG. 4.

FIG. 5.

FIG. 4. Retrograde ureterogram and pyelogram of the severe stricture using a No. 14 French ureteral catheter splint.

FIG. 5. The original preoperative pyelogram showing the hydronephrosis and long stricture of the proximal ureter.

The animals were kept on 300,000 units of penicillin daily for 5 to 6 days after operation and longer if necessary. No noticeable urinary drainage was seen in the wound as even the smallest diameter splints apparently drained adequately.

On the basis of the foregoing observation the following conclusions were reached: (1) A splint which must be forced into the ureter produces severe stricture formation, most severe at its distal end. (2) Pyonephrosis follows with marked periureteral and perirenal fibrosis, thus setting up a vicious cycle. (3) A small splint which is introduced with ease into the ureter drains adequately, produces no stricture formation, and leaves a more than adequate lumen in the regenerated segment. (4) A large soft splint causes damage while a small firm one does not. The lessons thus taught in the laboratory and method for correcting this condition are logically followed by a clinical counterpart.

CLINICAL MATERIAL

Several cases are presented for illustration of both the use of too large a splint and the clinical end result of a well placed catheter.

CASE 1. A 28 year old female had a pyeloplasty for the relief of symptoms of right flank pain with findings of grade II hydronephrosis and a ureteropelvic junction stricture of the right kidney. At operation there were moderate perinephric adhesions, the kidney was mildly increased in size with a granular appearing surface, and increased fibrous tissue was present at the ureteropelvic junction. Upon opening the renal pelvis, a No. 10 French catheter could not be passed more than 1 centimeter below the ureteropelvic junction with ease; however, with considerable pressure it was passed for 20 centimeters and the area over the ureteropelvic stricture was incised for 2 centimeters.

The straight nephrostomy tube was pulled out of position on the third postoperative day. It became nonfunctioning on the seventh postoperative day thus making reoperation necessary. At this time a large amount of purulent urine was found in the perinephric space and the pyelotomy wound had connected with the ureteral incision by necrosis. A No. 12 French latex rubber T tube was placed 5 centimeters down the

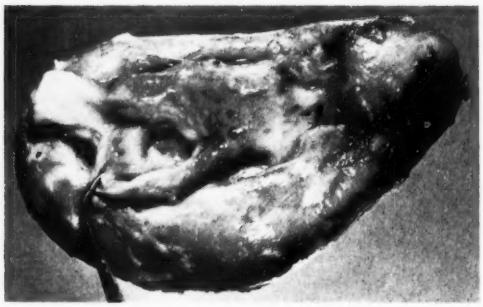

FIG. 6. Surgical specimen with special reference to the proximal ureter. Note the large caliber of the lumen and the ureteropelvic junction.

ureter where it fit tightly. The wound drained purulent urine for 4 days, but dried up, and the patient was discharged from the hospital 15 days after the second operation. The T tube was removed in 6 weeks.

Follow-up. There has been a very hard, fibrous stricture at the site of the end of the T tube, which was nearly impassable and required frequent dilatation up to the present time (Fig. 4). A No. 10 French bulb catheter can now be passed with some pressure, and the pain continues, but is somewhat relieved. Good function of the kidney has been maintained, however, and the pyuria has cleared in the past 20 months.

CASE 2. An 8 year old male had a right pyeloplasty on January 2, 1950 for symptoms of right flank pain and persistent pyuria, and findings of hydronephrosis with renal calculi (Fig. 5). At operation 12 urate calculi measuring 2 to 6 millimeters in diameter were removed. A large redundant pelvis was excised and the ureteropelvic junction showed a stricture for 1.5 centimeters. This was incised for a distance of 2.0 centimeters and a No. 10 French Davol rubber T tube was passed into the ureter without increased pressure. The postoperative course was uneventful.

Follow-up. A persistent pyuria and calculus formation began 12 months after healing. This condition persisted in spite of continued therapy and ureteral dilatations during the next 7 years. Later the patient began to complain of right flank pain. The calculus increased in size and began to produce hematuria while the function of the kidney was mildly reduced, and it was considered necessary to perform a right nephrectomy.

It is logical and natural for a surgeon to attempt to use the largest, softest catheter which can be placed into the ureter without excessive stretching of the diameter of the lumen. These patients were treated with intubated ureterotomy for long (over 1 cm.) strictures of the ureter. The opportunity to observe the status of a kidney 7 years after operation was fortunate (Case 2). While the clinical judgment to perform the nephrectomy was doubtful, the identical clinical observation was made as in the experimental animal; namely, that the lumen of the regenerated or incised area was larger in diameter than that of the splinting catheters (Fig. 6).

Clinically, the soft T tube is still employed in the same manner and for the same reasons as stated in our previous work; the reason for substituting a straight polyethylene tube in the experimental animal was purely a matter of sizes because the smallest Davol rubber T tube is a No. 8 French and the average dog ureter readily accommodates only between a No. 3 and No. 5 French size.

SUMMARY

Splinting catheters which stretch the ureter are seen both experimentally and clinically to produce severe stricture formation.

Small splinting catheters are accommodated without stricture formation in both the laboratory animal and the clinical patient.

Periureteral fibrosis is seen probably to result from intraureteral and intrarenal infection caused by the stricture which produces urine stasis.

With the use of smaller sized splints the regenerated or incised area will not contract, but will retain an adequate lumen.

REFERENCES

1. GREENE, L. F. Renal and ureteral changes induced by dilating ureter; experimental study. J. Urol., Balt., 1944, 52: 505–521.
2. WEAVER, ROBERT G., and HENDERSON, JAY H. Ureteral regeneration: experimental and clinical. J. Urol., Balt., 1954, 72: 350–357.

THE MANAGEMENT OF LINGUAL CANCER

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THE TONGUE is the most frequently involved site of cancer arising in the oral cavity. Malignant tumors of the tongue cause more deaths each year than any other head and neck cancer including thyroid neoplasms. In the head and neck region, the incidence of lingual cancer is second only to cancer of the lip (excluding skin cancer). It has been estimated that cancer of the tongue accounts for 2 to 3 per cent of all human cancer and approximately 1 to 2 per cent of all fatalities resulting from malignant disease. Thus, in terms of prevalence, the management of tongue cancer presents an important problem. The basis for this article is the experience gleaned from 102 consecutive cases of primary lingual cancer in patients admitted to the Head and Neck Service of the Ohio State University Hospital from 1948 through 1955. This relatively small series has provided 136 separate operative procedures for the purpose of cure or palliation. Furthermore, 35 per cent of the consecutive radical neck dissections at this institution were performed for the control of cancer of the tongue.

HISTORY

The ancient literature makes no specific reference to lingual cancer, although a treatment for "illness of the tongue" was described in the Ebers papyrus. The earliest incontestable description of cancer of the tongue was reported by Alexander Read in 1635, and another 29 years elapsed before Marchetti (1) attempted the surgical excision of a malignant lesion of the tongue. Glossectomy had formerly been used for centuries only as a punitive measure. In 1902, Dickson employed x-ray and Dominici introduced radium for the irradiation therapy of this neoplasm (11). The initial description of an interstitial implantation technique by Stevenson in 1914 furthered the cause of radiotherapy. However, the advent of the radical neck dissection by Crile in 1906, coupled with modern methods of asepsis, anesthesia, blood replacement, and antibiotics, has restored the surgical treatment of lingual cancer to its former eminence.

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CLINICAL FEATURES

Oral neoplastic disease occurs most frequently in the male, and cancer of the tongue offers no exception. Seventy-four patients of the total 102 cases in this study were men. The predominance of males does, however, fall somewhat below that reported by other investigators. It is also a well established fact that cancer of the tongue usually affects persons in the fifth or sixth decade of life. In this series, the average age was 62.4 years, with the oldest patient 93 years and the youngest 35 years. No appreciable age difference according to sex could be established.

The site of the lingual cancer was posterior to the circumvallate papillae in 47 patients, while the remaining 55 patients presented lesions anterior to this line. Of the latter group, in 45 persons the cancer was on the lateral border of the middle third of the tongue, 7 patients had the anterior third of the tongue afflicted, and only 3 patients were found to have their primary lesion located on the dorsum of the middle third of the tongue (diagrammatically represented in Fig. 1). Consequently, this series presents a predominance of basilar involvement with a lower prevalence of marginal lingual can-

TABLE I.—COMPARISON WITH PREVIOUS REPORTED SERIES

Series	*No. of cases*	*Average age, yrs.*	*Per cent males*	*Per cent syphilis*	*Distribution of lesions in percentages*				*Per cent patients with neck nodes on admission*
					Tip	*Dorsum*	*Lateral*	*Base*	
Berridge and James	102	62.4	72.6	12	7	3	44	46	40
Elkins	98	63.8	78.6	24	15	4	58	21	36.7
Gibbel *et al.*	330	52.6	Vet. Hosp.	21	13	*	29	48	31
Martin *et al.* (14)	556	58	87	33	9	0	58	33	35
Rahausen *et al.*	113	50–59	86.8						59.3
Sharp *et al.*	84	50–80	72.4		8	10	72	10	
Wood	192	65	88		**	9	21	43	63.8
Wookey *et al.*	342	62.7	80	8					36

*Undersurface 10 per cent.
**Undersurface 27 per cent.

cer. (See Table I for comparison with other reported series.) The average size of the primary lesion according to site was determined; and it was found that lesions arising at the tip of the tongue averaged 2.1 centimeters, those located on the dorsum presented a mean measurement of 2.8 centimeters, with 3.6 centimeters being the mean size for the lesions of the base (Fig. 2).

The average delay from the onset of symptoms to the institution of treatment was 4½ months. No significant difference appeared in the duration of delay for the cancers of the anterior two-thirds of the tongue, as compared with those of the posterior one-third, but the symptoms were strikingly different. The awareness of an oral mass, local tenderness, or burning pain was created by lesions appearing on the anterior tongue. Lesions on the base of the tongue often caused these complaints and, in addition, produced otalgia, dysphagia, or dysphonia. Twenty per cent of the patients with cancer of the base of the tongue had symptoms referable to metastatic involvement, as evidenced by complaints of cervical pain or a palpable neck mass.

Cervical node metastases were found in 40 per cent of all untreated patients at the time of admission to the hospital. The prevalence of cervical spread increased to 54 per cent when basal tongue lesions alone were considered. However, the incidence of bilateral cervical metastases was equal between lesions of the anterior two-thirds and those of the posterior one-third of the tongue. Systemic metastases were present on admission in only 2 patients and were derived from a primary squamous cell carcinoma of the base of the tongue in each case.

Syphilitic glossitis has long been considered a predisposing factor in carcinoma of the tongue. As antibiotic therapy diminishes the incidence of this infection, a corresponding decrease in serologically positive patients may be expected. Only 12 per cent of the patients with lingual cancer had a reactive serology on admission to this hospital. The mean age for this 12 per cent was 60.5 years, and only 1 female was in this group. In this survey, all luetic patients had a squamous cell type of carcinoma, and, with a single exception, the lesion was located anterior to the circumvallate papillae line.

Additional probable predisposing conditions were frequently encountered but were difficult to evaluate. Poor oral hygiene or dental sepsis was the most commonly associated finding. Others, listed in order of decreasing prevalence, were the use of tobacco, leucoplakia, and alcoholism. Avitaminosis was evident in a score of patients but was invariably associated with a large intraoral mass which precluded an adequate dietary intake.

Associated degenerative diseases were found, as might be expected, with an older age group. Concomitant cardiovascular or respiratory disease was a commonplace occurrence. A second primary neoplastic lesion of indisputably separate origin was detected by history or follow-up examination in 3 patients. It is worthy of note that 2 men had active pulmonary tuberculosis, while an additional male patient had apparently arrested intrathoracic acid-fast disease. A squa-

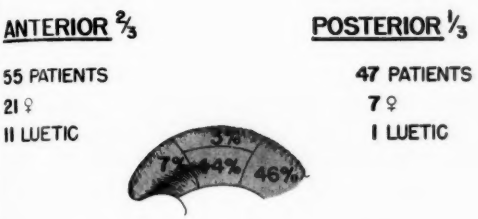
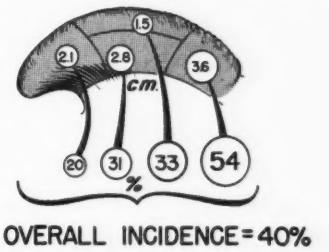


FIG. 1. Site of lesion, sex of patient, and incidence of syphilis in 102 lingual cancer cases.



OVERALL INCIDENCE = 40%

FIG. 2. Mean diameter of lingual lesion and incidence of cervical metastasis in 90 untreated patients.

mous cell carcinoma of the base of the tongue was found in each tuberculous patient.

PATHOLOGY

Ninety-eight per cent of the cancers occurring anterior to the foramen caecum proved to be squamous cell carcinoma, but at the base of the tongue only 79 per cent of the primary tumors were of this cytologic type. The other malignant tumors which were found on the posterior third of the tongue included: 3 cases of transitional cell carcinoma, 2 cases of adenocarcinoma, and individual cases of mucoepithelioma, mucinous adenocarcinoma, lymphosarcoma, lymphepithelioma, and reticulum cell sarcoma. Although 7 females developed cancer on the base of the tongue, only 4 of these were squamous cell lesions.

DIAGNOSIS

Only 2 patients were discovered with asymptomatic primary lesions in the course of a routine examination in this group of 102 patients. Considering the average delay of over 4 months from the onset of symptoms to treatment and the frequent association of medical or dental disease, it is surprising that so few cases of lingual cancer were detected before the malignant disease prompted admission to the hospital. The incidence of early detection will improve when a tongue depressor, a laryngeal mirror, a finger cot, and a good source of illumination are used to explore the oral cavity of all patients during routine physical examinations. Oral palpation is the only screening method readily available for detecting lesions appearing in the glossoepiglottic fossae and the posterior base of the tongue. Only rarely, in the presence of a hyperactive gag reflex, must a topical anesthetic spray such as 2 per cent pontocaine be used to permit this palpation. There is no contraindication to immediately performing a biopsy, once a suspicious lesion is detected (7). If the lesion proves to be inflammatory, or should neoplastic and inflammatory disease coexist, the course of the lingual disease is not altered by biopsy.

EVALUATION

The evaluation of a patient known to have cancer of the tongue provides no unusual problems. A detailed history and complete physical examination are invaluable. The location, appearance, and size of the lesion are noted, and some impression as to the infiltrative extent of the lesion is obtained by intraoral palpation. A confirmatory biopsy is obtained by employing a pair of biting biopsy forceps. This is readily accomplished under local anesthetic infiltration, and an area at the periphery of the ulcer or tumefaction is selected for removal. If neck nodes are palpable, an aspiration biopsy of the most suspicious cervical mass is performed immediately, and the tissue is submitted for cytologic examination.

The laboratory testing includes the routine complete blood count, serologic test for syphilis, and urinalysis. A blood urea nitrogen and fasting blood sugar are usually indicated on the basis of the patient's age, while

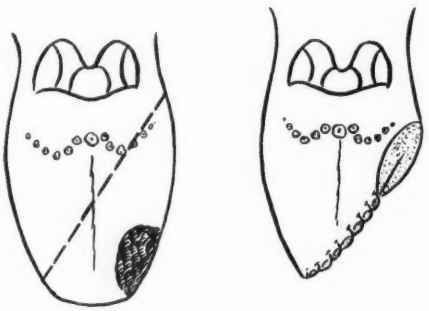


FIG. 3. Partial glossectomy. This procedure is suitable for cancers of anterior lateral margin or tip of tongue.

a prothrombin time determination serves as a screening test for liver disease and proper blood coagulability. Although a bedside vital capacity determination is performed on patients with questionable respiratory reserve and has proved to be a rough guide to operative risk, a chest film is required to detect distant metastases or associated cardiorespiratory disease. A careful history and physical examination will provide any indications for roentgenologic views of the teeth, mandible, or base of the skull, and for electrocardiographic evaluation of the heart.

The routine utilization of 1.5 per cent hydrogen peroxide mouth irrigations and the frequent brushing of teeth will contribute to satisfactory oral hygiene in patients prior to surgery, although dental consultation may be required for individuals with severe oral sepsis.

TREATMENT

The size, location, and type of primary neoplasm, as well as the extent of metastatic spread, dictate the therapeutic approach. Irradiation alone has been reported to control the oral lesion with fair results. It has been the opinion at this clinic and elsewhere that cancer of the tongue is primarily a surgical problem. Each lingual site of origin will be discussed individually.

Surgical Management of Tongue Lesion

Anterior third of the tongue. Small localized carcinomas of the anterior third of the tongue are readily extirpated by transecting the apex of the tongue obliquely. Traction sutures of No. 00 silk placed through the tongue edge lateral to the line of incision may be held by the operating assistant to facilitate the excision. A wide margin of normal tissue (preferably 2 centimeters in width) should be sacrificed on all sides of the lesion to insure complete excision. The procedure is illustrated in Figure 3.

A slightly V-shaped incision, as viewed in the horizontal plane, will avoid the appearance of a thick tongue and allows the closing sutures to be tied without tension. Tabs at the lateral margins of the incision are to be avoided as they interfere with the mastication of food postoperatively. This type of partial glossectomy can be performed easily and the functions of the tongue are only slightly impaired.

Lateral margins of the tongue. Lesions up to 3 centimeters in diameter appearing on the lateral border of the middle third of the tongue are remediable by hemiglossectomy. An extensive hemiglossectomy may occasionally be necessary but it has been our experience that the removal of a generous elliptical longitudinal wedge from the dorsolateral aspect of the organ usually controls the primary lesion.

Exposure is best accomplished by applying traction to the tip of the tongue such that it protrudes through the opposite labial angle. First, the ellipse is outlined by lightly incising the mucous membrane of the tongue. Then careful palpation of the musculature of the tongue for induration will insure a wide margin of normal tissue as dissection is carried out deep to the lingual lesion. A fine-tip suction catheter operated by the surgeon's assistant will keep the operating field clear of blood and, following the excision of the tumor, hemorrhage is easily controlled by individual clamping and ligation of vessels. The hypoglossal nerve trunk should be preserved when possible to avoid a unilateral flaccid tongue. The defect may be readily closed by approximating the tongue to the mucous membrane of the floor of the

mouth. A greater mobility can be afforded the remainder of the tongue by freeing up the attaching mucous membrane of the floor of the mouth. Should the lesion extend onto the floor of the mouth, this procedure is applicable, provided a 1½ to 2 centimeter margin of uninvolved tissue is obtained on all sides of the tumor. A rather extensive resection of the tongue is performed in this manner without altering the patient's speech to any incapacitating degree.

Dorsum of the middle third of the tongue. Malignant tumors of the dorsum of the tongue are elliptically excised and thereby controlled provided metastasis has not occurred. The long axis of a generous elipse may be directed in either the sagittal or transverse plane depending upon the size and configuration of the lesion. Strong traction applied to the tongue by towel clips, combined with a well padded mouth gag, affords excellent exposure of the operative field. Care must be exercised to avoid the inadvertent interruption of the hypoglossal nerve bilaterally. The continuity of the tongue is restored by closing the surgical defect with fine interrupted chromic catgut sutures.

Posterior third base of the tongue. Well lateralized lesions without cervical spread are removed through an intraoral approach as has been described for the middle third lateral tongue tumors. If a portion of the tonsillar pillar is involved, this is sacrificed to insure an adequate margin of resection and the mucous membrane defect is closed with minimal dissection of the contiguous structures.

More extensive lesions involving the base of the tongue are approached laterally because of the limited exposure of the operative area by the intraoral route. If necessary, the entire base of the tongue is resected and the middle third of the tongue sutured to the base of the epiglottis. This lateral pharyngotomy is always combined with a radical neck dissection, as will be discussed.

A few patients with lesions of the posterior third of the tongue will show extensive spread of the cancer onto the epiglottis or extrinsic larynx. A total laryngectomy, combined with a radical neck dissection and excision of the primary lesion, will be required for surgical cure in such cases. Despite the extensiveness of the resection, it is preferred to accomplish this as a one stage procedure if the condition of the patient will permit.

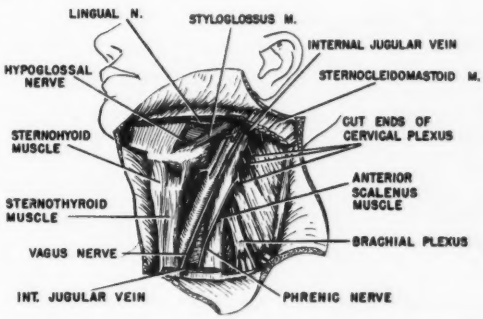


FIG. 4. Radical neck dissection. Illustrates dissected field at completion of this procedure. It is the operation of choice when cervical metastases are present.

Surgical Management of Involved Cervical Nodes

Extensive resections of the neck will be required when mitotic cells from malignant lesions of the tongue enter the lymphatic channels. The most commonly involved nodes are found along the deep cervical chain, especially at the carotid artery bifurcation. It has been the policy at this institution to await gross evidence of this metastatic spread before widening the scope of the local resection of the tongue, as suggested by Martin and his associates (13). Exclusive of distant visceral metastases, it is felt that there are few contraindications to a radical neck dissection, once palpable cervical nodes appear. There is unanimous agreement in the current literature that a radical neck procedure is the treatment of choice in the control of cervical metastases.

Radical neck dissection. This technical procedure has been extensively described by Huffman and by Martin (13) and their associates. It consists of removing the sternocleidomastoid and omohyoid muscles, the internal jugular vein, and the submaxillary salivary gland in block with the accompany-

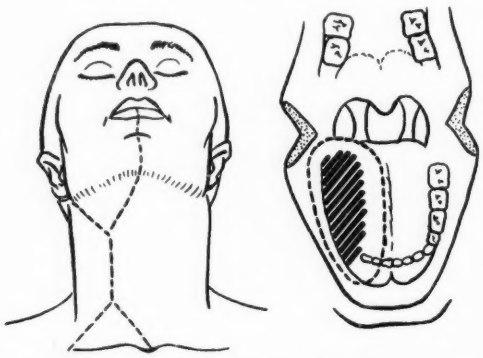


FIG. 5. "Commando" operation. So nicknamed because of its extensiveness. Used in cases of advanced cancer of the tongue with mandibular encroachment.

ing lymphatic channels from the level of the clavicle to the mandible. The appearance of the operative field following the completion of the radical prodecure is depicted in Figure 4. Any resection short of this extirpation has not been considered a true radical neck dissection. It has not been our experience with patients demonstrating cervical recurrence that the extension of the dissection medially as recommended by Pressman is warranted.

By extending the radical neck dissection, it is believed that the surgeon may extirpate an otherwise inoperable cervical involvement. There should be no hesitation to sacrifice neoplastically infiltrated structures, such as the digastric and mylohyoid muscles, the phrenic, vagus, and hypoglossal nerves, or the external carotid artery. Only the internal and common carotid arteries are considered vital structures because of the high, unpredictable mortality associated with the interruption of these vessels. These vital arteries may remain in continuity, and infiltrating residual tumor controlled by radioactive interstitial implantation as will be described later.

Combined lingual and cervical procedures. An en bloc procedure is applicable whenever unilateral cervical node metastasis occurs in association with an untreated or uncontrolled primary lesion of the tongue. It has been employed in the absence of demonstrable neck metastases only when a lateral approach to the lingual lesions was technically imperative. This operation consists of extending a standard radical neck dissection cephalad through the floor of the mouth (or the lateral pharyngeal wall) beneath the uninvolved mandible and accomplishing a generous partial glossectomy. This lateral submandibular approach to the tongue permits satisfactory exposure of the subglossal structures. The hypoglossal nerve is identified as it curves forward and upward, lateral to the hypoglossus muscle; and it is preserved unless infiltrated with tumor. An elliptical excision of the lingual lesion is facilitated by drawing the tongue out beneath the mandible through the lateral incision in the floor of the mouth. If conditions demand, an intraoral approach may be combined with the subglossal dissection of the lingual lesion, or transection of the uninvolved mandible can be performed to provide adequate exposure of the oral cavity. The latter procedure is followed by a reapproximation of the mandible with wire upon completion of the oral resection. A careful approximation of the mucous membrane of the oral or pharyngeal cavity is necessary to avoid mucocutaneous fistulization postoperatively.

It is evident from the foregoing discussion that extension of the tumor beyond the anatomic limits of the tongue will demand wider surgical excision. Particularly prone to involvement by direct extension is the mandible. Whenever a posterior lesion invades the faucial pillar or an anterior lesion involves the gingiva, hemimandibulectomy is indicated.

A commando procedure is used for primary lesions of the tongue (with or without accompanying cervical metastases) which have extended laterally to involve the gingiva, mandible, or its periosteal covering. Such a surgical procedure became universally accepted when the accumulated experience of radiotherapists demonstrated the inability of external radiation to deliver cancerocidal doses into the mandible. It has been the policy to perform a radical neck

dissection in block with the hemimandibulectomy and subtotal glossectomy whenever possible (Fig. 5).

The wide exposure of the oral cavity afforded by performing a hemimandibulectomy enables the surgeon to excise accurately large lesions of the tongue. A typical surgical specimen obtained from a commando procedure is depicted in Figure 6. Reference should be made to the work of Morfit, Slaughter and associates, and Sugarbaker and Gilford, for the surgical technique of this operation. The expanse of mandible removed varies according to the site and extent of osseous neoplastic involvement. In most anterior tongue cancers it is preferred to segmentally resect the mandible, whereas disarticulation is necessary in posterior third of the tongue lesions. The mental area of the mandible is frequently preserved in posterior and middle third carcinomas to improve the cosmetic result without jeopardy of cure.

No immediate attempt at plastic repair of the jaw configuration is made at the time of the commando procedure. An adequate period of time should elapse before undertaking prolonged and costly reconstructive operations because of the possibility of tumor recurrence. Most patients develop a psychologic adjustment to their deformity so that few persons will desire plastic procedures when eventually offered.

Anesthesia

A general anesthetic agent is always preferred whether resectional surgery or radioactive implantation is determined to be the treatment of choice. If a nasotracheal tube is inserted, the patient is provided with a safe airway and the operating surgeon is afforded a minimum of encumbrances. This intubation of the patient may be accomplished "blind" by an experienced anesthesiologist following an induction with pentothal-curare anesthesia. With proper draping technique on the part of the surgeon, the only portion of the anesthetic equipment which remains exposed is the short segment of intratracheal tube within the pharyngeal cavity. This is cleansed with an aqueous zepharin preparation and packed off from the operative field when an intraoral procedure is employed. A more detailed description of the intubation technique and the routine aseptic draping of the operative field has been presented in an article written by Martin (12).

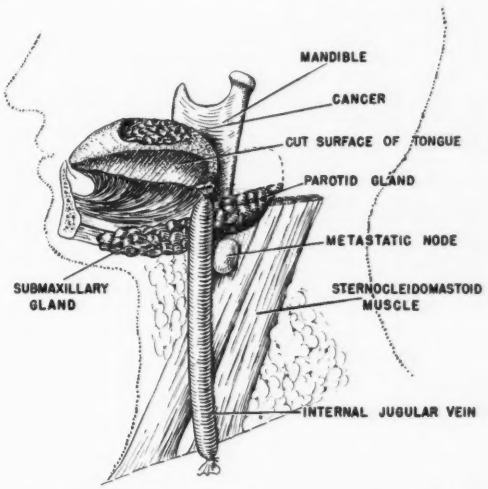


FIG. 6. Surgical specimen from commando procedure. Removed by operation described in Figure 5, this specimen consists of parts of tongue, mandible, floor of mouth, and neck dissection specimen.

Postoperative Maintenance

A temporary tracheostomy is performed routinely immediately following a commando procedure or a radical neck dissection which has been combined with pharyngotomy. There is no hesitation to perform an elective tracheostomy at any time during the postoperative period when the adequacy of the airway is doubtful, and on no occasion has there ever been cause to regret this principle. The postoperative care of a tracheostomy is well established and need not be described here. If the oral airway appears to be adequate, the tracheostomy tube is closed with a small cork on the second or third day following surgery. The tolerance of a nonfunctioning tracheostomy tube for a few

FIG. 7. Radiogram of interstitial implants. Nylon applicators containing radioactive sources implanted simultaneously with hemimandibulectomy.

hours' period should be conclusive evidence that the apparatus may be removed with safety.

Fluid, electrolyte, and caloric requirements are met by nasogastric tube feedings. A small diameter polyethylene feeding tube is easily inserted prior to surgery whenever an intraoral or pharyngeal incision is contemplated. The nasogastric tube eliminates the contamination of the mucous membrane suture line by food, decreases the need for painful motion of the tongue, and minimizes the disruption of the healing incision coincident with excessive deglutition. Two liters of fluid and 1,200 calories are provided by homogenized milk alone. Amounts of 360 cubic centimeters are instilled into the feeding tube followed by 40 cubic centimeters of water at 3 hour intervals during the day. A liquid vitamin preparation rich in vitamins B and C content is added to the daily requirement of milk. The feeding tube is not removed until the suture line has healed well, which is usually on about the tenth postoperative day.

The well established surgical principle of early ambulation is easily accomplished in these patients. Male patients are permitted to stand to void during the evening of surgery. Irrespective of age or sex, the postoperative patients are encouraged and assisted in walking during the morning and afternoon of the day following surgery. Actual perambulation, rather than sitting, is preferred. The facility with which ambulation is executed may in part explain the paucity of thromboembolic phenomena in these patients.

Comfortable and therapeutic oral hygiene is attained by employing a 1.5 per cent solution of hydrogen peroxide, followed by a saline mouth rinse, 4 times daily. A fine stream oral irrigation apparatus has proved of value in this regard by providing a dynamic force sufficient to wash away adherent mucus coating.

Antibiotic therapy has greatly decreased the morbidity and mortality due to infection following major head and neck operations during the past decade. Based upon the normal and pathologic bacterial flora of the oral cavity, the drugs of choice are penicillin and streptomycin.

The bulky pressure dressing of the radical neck and commando procedures are changed initially on the fourth postoperative day and reapplied on alternate days thereafter. Thus an equality of compression is provided and excessive localized pressure is eliminated as a cause for skin necrosis. The subcutaneous drains are usually removed at the time of the initial dressing change. Skin sutures are removed on the sixth to eighth postoperative day as a general rule, whereas nonabsorbable sutures of the mucous membrane are usually withdrawn by the tenth day following surgery.

Radiation Therapy

The indications for radiation therapy in lingual cancer are as follows: (1) massive involvement of the tongue or its contiguous structures associated with bilateral cervical nodes; (2) midline, middle third, radioresi-

tive lesions with bilateral neck metastases; (3) large neck masses which are adherent to the internal or carotid arteries and to other deep structures; (4) extension to the base of the skull with invasion of the periosteum; (5) lymphomas of the lingual tonsil or the base of the tongue; (6) local recurrence in the deep structures of the neck following a radical neck dissection; (7) evidence of distant metastatic spread; (8) residual cancer tissue after radical surgical resection.

Externally applied irradiation therapy has been especially difficult in head and neck cancer because of the topographic irregularities of the regional anatomy. The problem is increased when a large irregularly shaped tumor appears in close proximity to vital structures. Under such conditions it is nearly impossible to deliver cancerocidal doses of external irradiation to all portions of the tumor without producing undesirable side effects.

Interstitial irradiation. Interstitial implantation has been superior to external irradiation therapy for achieving a uniform dosage within tumors of the area. During the years 1948 through 1955, three radioelements have been used to this purpose. Radioactive Cobalt, gold, and iridium, were employed in that order. The ideal element should be inexpensive, yet have the advantages of radium without any of its undesirable physical properties (8). Radioactive iridium, with a half life of 74 days, is obtained in the form of wires from the Oak Ridge Laboratories. These wires are placed within tiny shielding cylinders and then cut into short segments of desired strength. The small segments, or "seeds," are loaded into hollow nylon threads at 1 centimeter intervals and autoclaved to achieve sterility. The outside diameter of these flexible nylon threads is comparable to No. 4 silk tension material. The equipment necessary for the monitoring and cutting of these radioactive seeds is inexpensive and readily obtained (5).

The technique of interstitial implantation is simple and can be performed under local anesthesia if desired (9). The skin is prepared

FIG. 8. Radiogram of interstitial implants. Implantation of threads performed as a separate procedure. Cervical recurrence followed unilateral radical neck dissection in this case.

in the operating room and the region is draped in the usual manner as for a commando dissection. Straight Keith or curved tension needles are inserted through the tumor mass parallel to each other at estimated 1 centimeter intervals. If the area to be implanted is large, other planes of needles are inserted at 1 centimeter from the initial plane and this is continued until the area to be treated has been covered. Nylon threads containing radioactive isotopes are then pulled into place and small metal washers are crimped flush with the skin surface to prevent slippage or untimely withdrawal. These "loaded" sutures are well tolerated in the oral cavity or in the neck for the required 6 to 10 days and are easily withdrawn without anesthesia (10). A regular pattern is created by maintaining a 1 centimeter interval of needle insertion. This is desirable because it delivers a uniform irradiation within the tumor mass and greatly simplifies the dosage calculation of the implanted seeds. However, an irregular pattern

is often used, either of necessity or by choice. The major blood vessels and the osseous structures of the region cannot be transfixed by the nylon sutures and must therefore be circumvented. The surgeon may choose to alter the pattern by implanting sutures at less than 1 centimeter intervals to provide intensified radiation to a certain area, rather than accomplish this by loading an individual nylon thread with seeds of greater radioactivity. Whenever an irregular pattern is employed, a postimplantation roentgenogram is required to calculate accurately the effectiveness of each radioactive seed.

Neoplastic involvement of the base of the skull, the carotid artery, or the deeper structures of the neck is not always detectable preoperatively. Upon completion of the remainder of the resection, interstitial implantation of the tumor residuum is performed under direct vision. It is the incorporation of this procedure as an integral part of the dissection which has led to the particular enthusiasm for interstitial radioactive implantation by members of the surgical service.

A tumor dose of 6,000 roentgens is delivered whenever possible by the interstitial implant technique. Externally applied deep x-ray irradiation is used to supplement the interstitial source when the need exists. The application of external irradiation alone has been utilized most infrequently because of the handicaps previously mentioned as associated with its use.

CLINICAL MATERIAL

In this series of 102 patients, all but 4 patients received surgery, interstitial irradiation, or a combination of both as therapy for lingual cancer. Of the remaining 4 patients, 2 persons were admitted to the hospital in terminal condition and expired before definitive treatment could be instituted; 1 patient was transferred to a veterans' hospital after the diagnosis was performed; and in the final case, the patient refused any form of therapy.

During the 8 years included in this report, 37 partial glossectomies were performed as separate procedures; and, in an additional 2 instances, glossectomy was combined with radioactive implantation. A commando or radical neck dissection was employed on 34 occasions, and was accompanied by simultaneous interstitial implantation of radioelements in another 7 instances. A radical neck dissection en bloc with excision of the lingual primary lesion was accomplished for 11 patients. The implantation of interstitial radioactive material as a separate surgical procedure was carried out on 23 occasions. Three patients required total laryngectomy for control of the tumor. Six hemimandibulectomies were performed as a preliminary procedure to subsequent irradiation therapy or because of tumor recurrence following a radical neck dissection. Palliative submandibular and submental node dissections were accomplished in 2 poor risk patients. Eleven additional surgical procedures were performed, the majority of which were for palliation, rather than cure.

Three deaths were attributable to surgical intervention in the treatment of the lingual carcinoma. The first patient expired on the fifth day following a bilateral prefrontal lobotomy for the relief of pain. The second patient, a 79 year old male, with a lesion on the base of the tongue, died of bronchopneumonia on the fifth day after a simultaneous left radical neck dissection and radioactive iridium implantation of tumor residuum. The final patient, age 69 years, expired late in the evening of the first postoperative day from unrecognized acute gastric dilatation following malpositioning of the oxygen catheter. The over-all operative mortality was 2½ per cent.

DISCUSSION

Conclusions derived from a modest series of 102 patients are perhaps statistically contestable, but certain clinical findings are apparent. Cancer of the tongue might be considered as two different diseases, depending upon whether it arises anterior or posterior to the circumvallate papillae. The anterior tongue cancers are nearly exclu-

sively squamous cell carcinomas and are usually located on the lateral margin. The initial symptoms are invariably attributable to the growth itself, thus affording an early detection of the lesion. In spite of this, approximately one-fourth of these patients have palpable cervical nodes upon admission to this hospital. The majority of our female patients with squamous cell carcinoma have their tumors located anterior to the circumvallate papillae. By contrast, cancer of the posterior third of the tongue appears more frequently in the male and the predominance of squamous cell carcinoma is less marked. Symptoms are attributable to the direct extension of the primary tumor or to the metastatic spread. When eventually discovered, the primary lesions are usually large and palpable cervical lymph nodes were evident on admission in 54 per cent of the patients with cancer of the base of the tongue. The poor prognosis associated with all cancers in this location is well recognized; but whether it is due primarily to a greater malignant potential of these tumors, the excessive delay accompanying the symptomless primary lesion, or the direct lymphatic spread into the deep cervical chain is open to conjecture.

Syphilis appeared to be a significant predisposing factor only for squamous cell carcinoma arising on the anterior two-thirds of the tongue. The decreasing incidence of syphilis in the general population and the increasing tobacco habit in women may account for two discrepancies of this survey, as compared with other reported series. First, the men do not predominate greatly, particularly in the group of persons found to have cancer of the anterior two-thirds of the tongue. Secondly, there is a decreased incidence of the anterior two-thirds lesions as compared with other series. Thus, it seems that possibly oral hygiene and smoking, rather than syphilis, are playing a more decisive role in the predisposition for cancer of the tongue.

It is believed that the surgical treatment of lingual cancer is most uniformly successful. Without palpable evidence of lymphatic metastasis, the primary tongue tumor can be easily excised with little jeopardy of life or inconvenience to the patient. More extensive dissection is required in the presence of mandibular, cervical, or epiglottic involvement; or surgery may be coupled with interstitial implantation of radioactive iridium to obviate the need for occasional operative sacrifice of the common carotid or internal carotid arteries and to sterilize other sites of nonresectable tumor tissue. External radiation therapy has been employed chiefly as an adjunct to interstitial irradiation.

SUMMARY

Certain clinical and pathologic aspects of 102 consecutive patients found to have cancer of the tongue are discussed. The technical aspects of the surgical treatment of lingual tumors are mentioned and the applicability of the method of interstitial implantation irradiation is described. The management of lingual cancer is recorded as employed on the general surgical service of this hospital.

REFERENCES

1. Butlin, H. T., and Spencer, W. G. Diseases of the Tongue. 2nd ed. London: Cassell & Co., 1900.
2. Crile, G. W. Excision of cancer of the head and neck with special reference to the plan of dissection based on one hundred and thirty-two operations. J. Am. M. Ass., 1906, 47: 1780–1786.
3. Elkins, H. B. Carcinoma of the tongue. Am. J. Roentg., 1952, 68: 81–88.
4. Gibbel, M. I., Cross, J. H., and Ariel, I. M. Cancer of the tongue; a review of 330 cases. Cancer, 1949, 2: 411–423.
5. Henschke, U. K., James, A. G., and Myers, W. G. Radiogold seeds for cancer therapy. Nucleonics, 1953, 11: 46–48.
6. Huffman, W. C., and Lierle, D. M. Dissections of the neck. Plastic & Reconstr. Surg., 1953, 11: 115–146.
7. James, A. G. Cancer of the tongue. Ohio M. J., 1950, 46: 1184–1185.
8. James, A. G., Henschke, U. K., and Myers, W. G. The clinical use of radioactive gold (Au ^{198}) seeds. Cancer, 1953, 6: 1034–1039.
9. James, A. G., Williams, R. D., and Morton, J. L. The use of radioactive cobalt in non-resectable head and neck cancer. Cancer, 1951, 4: 1333–1336.
10. Idem. Radioactive cobalt as an adjunct to cancer surgery. Surgery, 1951, 30: 95–105.
11. Martin, H. E. The history of lingual cancer. Am. J. Surg., 1940, 48: 703–716.
12. Idem. Radical surgery in cancer of the head and neck: the changing trends in treatment. Surg. Clin. N. America, 1953, 33: 329–350.

13. Martin, H. E., Del Valle, B., Ehrlich, H., and Cahan, W. G. Neck dissection. Cancer, 1951, 4: 441–499.
14. Martin, H. E., Munster, H., and Sugarbaker, E. D. Cancer of the tongue. Arch. Surg., 1940, 41: 888–936.
15. Morfit, H. M. Management of head and neck cancer by the general surgeon. Arch. Surg., 1952, 64: 631–646.
16. Pressman, J. J. Extended retrohyoid radical neck dissection for cancer of the oral cavity and neck. Surg. Gyn. Obst., 1955, 100: 329–344.
17. Rahausen, A., and Sayago, C. Treatment of cancer of the tongue. Am. J. Roentg., 1954, 71: 243–250.
18. Read, Alexander. The Chirurgicall Lectures of Tumors and Ulcers. Treat. 2, Lect. 26, p. 313. London, 1635.
19. Sharp, G. S., Demaree, E. W., and Pugh, R. E., Jr. Radiation versus surgery for cancer of the tongue. West. J. Surg., 1950, 58: 257–270.
20. Slaughter, D. P., Roeser, E. H., and Smejkel, W. F. Excision of the mandible for neoplastic disease. Surgery, 1949, 26: 507–522.
21. Stevenson, W. C. Preliminary clinical report on a new and economic method of radium therapy by means of emanation needles. Brit. M. J., 1914, 2: 9–10.
22. Sugarbaker, E. D., and Gilford, J. Combined jaw resection neck dissection for treatment of metastatic carcinoma of cervical neck nodes secondarily involving the mandible. Surg. Gyn. Obst., 1946, 83: 767-777.
23. Wood, C. A. P. The technique and results of treatment of cancer of the tongue with the use of a 10 gram radium beam unit. Am. J. Roentg., 1950, 63: 727–738.
24. Wookey, H., Ash, C., Welsh, W. K., and Mustard, R. A. The treatment of oral cancer by a combination of radiotherapy and surgery. Ann. Surg., 1951, 134: 529–540.

BENIGN TUMORS OF THE LIVER

III. Solitary Cysts

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NONPARASITIC CYSTS of the liver may be single or multiple, unilocular or multilocular, localized or diffuse. They may originate as congenital or acquired lesions, and their lining may be epithelial or fibrous. The contents of the individual cysts may be thin watery fluid, a thick viscid semigel, blood, bile, or pus, depending on the cause, the lining membrane, and such secondary features as infection, hemorrhage into the cyst, or degeneration of the cyst.

Simple unilocular cysts are relatively common but they rarely reach sufficient size to cause symptoms. When they do, the decision as to their management must be made at the time of operation, since the diagnosis is rarely made before surgical intervention.

Our study of benign tumors of the liver at the Mayo Clinic, of which this is the third part, uncovered 38 instances of simple unilocular cysts of the liver from 1907 to 1954, inclusive. Eleven of these patients were operated on because of symptoms or signs directly related to the tumor and another patient came because of symptoms produced by the tumor but died before surgical treatment could be given. These 12 patients make up group A. The lesions were found incidentally at operation for some other condition in the remaining 26 patients (group B).

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Abridgment of portion of thesis submitted by Dr. Henson to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

Dr. Howard K. Gray now deceased.

REVIEW OF THE LITERATURE

The association of cystic disease of the liver with cystic disease of the kidneys was first reported by Bristowe, in 1855. Several theories concerning the pathogenesis of hepatic cysts had evolved by the time Moschcowitz comprehensively summarized the many views that had been held up to 1906. He presented evidence that such cysts arose from aberrant bile ducts and had their origin from either congenital obstruction of these ducts or obstruction caused by inflammatory hyperplasia. Boyd, in 1913, collected data in 34 cases of cystic livers reported in the literature. Jones noted a total of 60 cases in 1923, and added a case of his own; Stoesser and Wangensteen found reports of 104 cases in 1929. In 1937, the extensive study of Davis (3,4) revealed a total of 499 cases. Of this total, 226 lesions were found surgically and 273 were noted at necropsy; 187 were solitary unilocular cysts, 20 were solitary multilocular cysts, 241 were multiple cysts, and 51 were not classified as to type. Since then, McCaughan and Rassieur, in 1938, and Munroe, in 1942, have presented excellent reviews of hepatic cystic disease.

SYMPTOMATIC SOLITARY CYSTS (GROUP A)

As stated, 12 patients had symptoms or signs produced by hepatic cysts (Table I).

Clinical features. Eight women, 3 men, and an 11 year old boy were included in group A. The average age was 50 years, with a range from 11 to 72 years. The average duration of symptoms at the time of admission was approximately 3 years.

TABLE I.—SYMPTOMATIC SOLITARY HEPATIC CYSTS IN 12 CASES

	Clinical features					*Lesion*		
Case	*Age, years*	*Sex*	*Chief complaint*	*Duration of symptoms*	*Roentgenologic findings*	*Size, cm.*	*Site, lobe*	*Follow-up, years*
1	60	F	Pain	5 weeks	—	Grapefruit	R	3
2	72	F	Urethral caruncle	—	Deformed stomach	4	Quadrate	—
3	47	M	Pain	5 years	—	6	R	10
4	36	M	Mass	1 month	—	Grapefruit	R	23
5	24	F	Pain	5 years	Mass, displaced kidney	40	L	21
6	67	F	Loss of weight, weakness	5 months	—	11	L	Died before operation could be done
7	62	F	Pain	5 years	—	15	R	17
8	53	F	Pain	4 years	Mass	8	R	17
9	55	F	Mass	4 years	Mass, elevated diaphragm	18	R and L	7
10	67	M	Pain	1 year	—	10	R	4
11	56	F	Mass	2 months	Mass	17	R	3
12	11	M	Fistula	11 years	Elevated diaphragm, calcification	7	R	—

The principal symptoms of these patients were pain in 6, a mass in 3, loss of weight and strength in 1, a persistent sinus tract after drainage of a hepatic cyst in 1, and a urethral caruncle in 1 patient, a woman who was unaware of a palpable mass in the right upper quadrant of the abdomen. The pain was of two types. One consisted of a dull ache, usually constant but aggravated by motion or when the patient assumed certain positions, such as lying down. The other type consisted of intermittent episodes of fairly severe and often sharp pain that sometimes required use of narcotics for relief. Two patients had chills and fever with residual soreness for several days after each episode of pain. The first type of pain presumably was related to the size and weight of the tumor, and the latter type of pain was caused by bleeding into, or rupture of, a cyst.

The mass usually was associated with vague abdominal discomfort, such as bloating, fullness, and flatulence; diarrhea was present in 2 patients. One patient, a 67 year old woman, complained of progressive weakness and loss of weight for 5 months and vague generalized abdominal pain, vomiting, and diarrhea for 4 weeks. She was found to have a large epigastric mass and to be in severe fluid and electrolytic imbalance. She became irrational, went gradually into coma, and died of hepatic insufficiency on the second day after admission. Necropsy disclosed the left lobe of the liver to be replaced entirely by a large cyst containing 450 cubic centimeters of opalescent fluid, whereas the right lobe was atrophied; hemorrhage had occurred from multiple points in the intestines, the bladder, and the kidneys, and chronic cholecystitis with cholelithiasis was present.

Examination disclosed that 10 of the patients had palpable masses and 1 had a sinus tract. One patient was thought to have signs of cholecystitis with cholelithiasis. The masses moved with respiration, were slightly tender in 4 patients, and varied in consistency from soft and cystic to hard and solid. Masses were confined to the right upper quadrant in 4 patients, to the epigastrium in 3, and to the left upper quadrant in 1, whereas they extended to the umbilicus or beyond in 2 patients. The size was not stated in 2 instances.

Laboratory findings. Studies of hepatic function were carried out on 6 patients. Significant abnormalities were absent.

Roentgenologic findings. Roentgenograms showed some abnormality in 6 of the 12 patients. Soft tissue masses were present in 4 patients, elevation of the diaphragm in 2, displacement of the kidney in 1 (Fig. 1), deformity of the stomach in 1, and irregular calcification throughout the tumor in 1. Some patients had more than 1 change.

Diagnosis. A preoperative diagnosis of an abdominal cyst was made in 4 patients. One

of these had had a hepatic cyst drained 9 years before and had a persistent draining sinus. The second patient was thought to have a hydatid cyst of the liver, the third a pancreatic cyst, and the fourth a retroperitoneal cyst. A diagnosis of an indeterminate abdominal mass was made in 3 patients, cholecystitis with cholelithiasis in 3, carcinoma of the stomach in 1, and a hepatic tumor in 1 patient.

Pathologic features. The cyst was found at operation or necropsy to involve the right lobe in 8 instances, the left lobe in 2, the quadrate lobe in 1, and both the right and left lobes in 1. The size varied from 4 to 40 centimeters, with an average of 10.8 centimeters. The cysts were described as translucent, thin-walled, and containing clear or amber fluid in 5 instances. Brownish-black or bloody fluid was present in the lesions in 3 patients, all of whom had the episodic type of pain, thus tending to confirm the belief that rupture or bleeding was the cause of this pain. One patient had 2 cysts, both of which were shelled out of the right lobe. Another patient had a cyst containing about 5 liters of clear fluid. This cyst appeared to originate in the right lobe, however, there was almost equal extension into the left lobe.

Histologically, the cysts were simple unilocular structures. The lining membrane consisted of cuboidal epithelium resembling normal bile duct epithelium (Fig. 2a) in 6 patients, columnar epithelium in 1 patient, and squamous epithelium in 1 (Fig. 2b). The lining was indeterminate in 4 cysts, in which it was thought to have desquamated as a result of pressure or inflammatory reaction. Variable amounts of fibrous tissue were present in the walls of the cysts, this component being relatively thicker in the larger lesions. Proliferation of bile ducts and dilated vascular channels occasionally were seen in the connective tissue walls. Mild to moderate infiltration by lymphocytes was present in some zones.

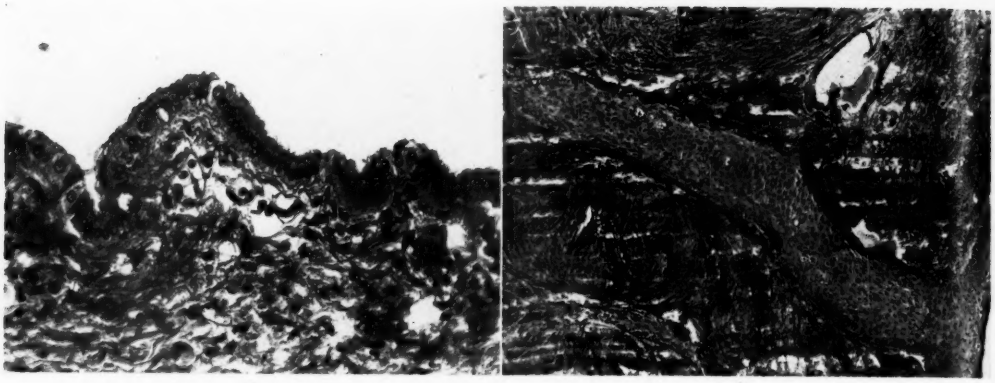
Treatment. Four of the cysts were excised, 3 were enucleated, and 4 were partially excised; as mentioned previously, 1 patient died before operative treatment could be considered. The cavity of the cyst was obliterated by suture in 1 case, packed with gauze in 2 cases, and filled with a tampon of omentum in 1 case. Other conditions found and treated at the time of operation consisted of gallstones in 3 patients, a duodenal ulcer in 1 patient, and appendicitis in 1 patient. A gallbladder that was attached to the cyst had to be removed along with the cyst in 1 patient.

FIG. 1. Case 5. Note downward displacement of left kidney by a large soft tissue mass that proved to be a simple cyst involving the left lobe of the liver. The cyst was lined by squamous epithelium.

There were no operative deaths. Nine patients in group A have been followed for periods ranging from 3 to 23 years, with an average of 11 years. Two patients have not been heard from. Known recurrence has not taken place.

SOLITARY CYSTS FOUND INCIDENTALLY (GROUP B)

Of the 26 patients who had unilocular simple cysts of the liver found incidentally at operation, 17 were women and 9 were



a b

FIG. 2. a, Wall of simple hepatic cyst showing cuboidal epithelium similar to that lining normal bile ducts. This is the type of epithelium usually found in simple unilocular cysts. Hematoxylin and eosin, ×230. b, Case 5. Wall of a simple cyst of the liver showing squamous epithelium. The cyst was 40 centimeters in diameter and involved the left lobe. Hematoxylin and eosin, ×70.

men. The average age was 55.8 years, with a range of 33 to 78 years. The cysts were all small, averaging 2.6 centimeters in diameter in the 14 instances in which definite measurements were given; the largest was 5 centimeters. They involved the right lobe in 14 patients, the left lobe in 1 patient, the hepatic notch in 1, and the suspensory ligament in 1; the site was not stated in 9 patients. Most of these small cysts were excised as material for biopsy during operations for disease of the biliary or gastrointestinal tract.

FIG. 3. Wall of a simple hepatic cyst showing ciliated columnar epithelium. This was 1 of 4 simple cysts showing ciliated epithelium, the presence of which is difficult to explain in this location. Hematoxylin and eosin, ×590.

Clinical or laboratory manifestations of the cysts were absent in this group of patients. Histologically, the lesions were similar to those in group A, with flat to cuboidal epithelium and varying amounts of fibrous tissue in the walls. The lining epithelium was ciliated (Fig. 3) in 4 cysts of this group, and it was indeterminate in another 4 cysts.

Eleven patients in group B have been followed for periods of 1 to 25 years, with an average of 10 years. None have shown any evidence of recurrence of the cyst.

COMMENT

The clinical and pathologic features of simple cysts frequently are similar to those of polycystic disease, and the pathogenesis is undoubtedly the same in many instances. Solitary cysts, however, appear to represent a localized process and one would expect localized factors to be etiologically significant in many instances, although this is difficult to prove in individual cases. The various types of epithelium found in solitary cysts and the occasional association with inflammatory processes suggest more than one factor in pathogenesis. Localized conditions that may result in the formation of solitary cysts include congenital aberrant bile ducts or blood vessels, obstruction of a

bile duct as a result of injury or inflammation, neoplastic transformation of epithelial tissue, or localized changes secondary to hemorrhage or degeneration.

The walls of a solitary cyst of the liver may be thick or thin depending on the amount of fibrous tissue. The lining epithelium is usually made up of flat or cuboidal cells similar to those lining normal bile ducts. Our series included cysts with tall columnar epithelium, mucus-producing epithelium, ciliated epithelium, and even squamous epithelium (epidermoid cysts?). Traumatic cysts, by contrast, have no epithelial lining.

The symptoms produced by solitary cysts of the liver, like those of other benign tumors of the liver, consist of pain in about a third of the patients, a mass in about a third, and symptoms caused by pressure on neighboring viscera in the remainder. Almost all patients who have symptoms will be found to have a palpable mass. Of special interest is the 1 patient in group A who died before surgical treatment could be attempted. One wonders whether the hepatic insufficiency was caused by pressure from the large solitary cyst or by chemical changes in the blood secondary to the prolonged vomiting and diarrhea prior to admission.

Complications that have arisen from solitary cysts of the liver include perforation, hemorrhage, inflammation, and torsion, if the cyst is on a pedicle.

Treatment of simple unilocular cysts of the liver should be total excision, if that is possible. This operation is frequently accomplished without difficulty if the cyst is on a pedicle or is easily accessible on the anterior edge of a lobe. Occasionally, they can be shelled out of the liver with little bleeding. Wedge resection is necessary at other times and is done usually after a row of interrupted sutures of catgut is placed for hemostasis. Partial excision, with packing of the remainder of the cavity, appears to give good results, as shown in 4 of the cases in the present series. The high mortality rates reported by Davis (22.2 per cent) and by McCaughan and Rassieur (23.07 per cent) suggest that a more conservative approach might be indicated. Operative deaths did not occur in the present series, although 1 patient died before she could be made ready for operation.

SUMMARY AND CONCLUSIONS

A study was made of the records in 38 patients who had simple unilocular cysts of the liver and who were seen at the Mayo Clinic between 1907 and 1954, inclusive. Eleven patients were operated on because of clinical manifestations thought to be caused by the hepatic tumor; a twelfth patient had symptoms produced by the cyst but died before surgical treatment could be instituted. Hepatic cysts were found in the remaining 26 patients during the course of an operation for some other condition.

Solitary cysts of the liver are relatively common but they seldom reach sufficient size to cause symptoms. When they do, the decision as to their management is usually made at the time that the operation is performed, because a preoperative diagnosis is rarely made.

The clinical manifestations of solitary cysts of the liver are similar to those of other benign tumors of the liver. These include pain, the presence of a mass, and symptoms produced by pressure on adjacent viscera. The pain may be of two types, namely a dull ache as the result of the size and weight of the tumor, or a sudden sharp pain with residual soreness that may last several days and is thought to be caused by rupture of a cyst or hemorrhage.

Simple unilocular hepatic cysts may have any type of epithelium and may be filled with material that varies from a clear watery fluid to a thick viscid semigel. They are occasionally quite large and should be excised if this can be done safely, but partial excision and obliteration of the cavity by suture or packing seem to give satisfactory results.

Complications of solitary cysts include perforation, spontaneous hemorrhage, infection, or torsion, if the cyst happens to be on a pedicle.

REFERENCES

1. Boyd, Sidney. Non-parasitic cysts of the liver. Lancet, Lond., 1913, 1: 951–959.
2. Bristowe, J. S. Cystic disease of the liver, associated with similar disease of the kidneys. Tr. Path. Soc. London, 1855–1856, 7: 229–235.
3. Davis, C. R. Liver cysts, non parasitic. Grace Hosp. Bull., Detr., 1936, 20: 2–48.
4. Idem. Non-parasitic cysts of liver. Am. J. Surg., 1937, 35: 590–594.
5. Jones, J. F. X. Removal of a retention cyst from the liver. Ann. Surg., 1923, 77: 68–89.
6. McCaughan, J. M., and Rassieur, Louis. Non-parasitic cysts of the liver; a report of two cases and an analysis of the literature. Tr. West. Surg. Ass., 1938, 48: 209–239.
7. Moschcowitz, Eli. Non-parasitic cysts (congenital) of the liver, with a study of aberrant bile ducts. Am. J. M. Sc., 1906, 131: 674–699.
8. Munroe, H. S., Jr. Contribution to the study of solitary nonparasitic cysts of the liver. Ann. Surg., 1942, 116: 751–762.
9. Stoesser, A. V., and Wangensteen, O. H. Solitary nonparasitic cysts of the liver. Am J. Dis. Child., 1929, 38: 241–257.

NYLON AS A VASCULAR PROSTHESIS IN EXPERIMENTAL ANIMALS WITH TENSILE STRENGTH STUDIES

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IN THE PAST DECADE much has been accomplished toward finding a satisfactory substitute for replacement of segments of blood vessels lost as a result of disease, trauma, or congenital deformities. Voorhees and associates reported good results with vinyon "N" in 1952. Since that time others have reported good results with a variety of synthetic materials. Nylon was advocated by Shumacker and Edwards because of its strength and inertness. The present article is a report of the results obtained with nylon grafts used in replacing segments of the thoracic aorta in 28 dogs.

METHOD

A calendered[1] weave of nylon was used (Table I) (Fig. 1). The material was boiled in water and a detergent to remove any plasticizers. Grafts were made to the appropriate size by folding the cloth and sewing with a sewing machine (Fig. 2). The ends were sealed by flaming over a Bunsen burner. This procedure made turning cuffs unnecessary.

Adult mongrel dogs were used in the study. All were anesthetized with intravenous sodium pentobarbital. Endotracheal tubes were inserted and oxygen given by intermittent positive pressure with a pneophore valve.

The thoracic cavity was entered through the fifth interspace and the thoracic aorta exposed from the arch distally for 6 centimeters. Six pairs of intercostals were divided and ligated. A polyethylene shunt was placed between the subclavian artery and descending thoracic aorta during the period of occlusion. A segment of aorta was excised between Potts clamps and replaced with a graft of the same diameter and 3 to 8 centimeters in length. Most of the anastomoses were done with interrupted everting mattress sutures of No. 5-0 arterial silk. A continuous over-and-over suture of the same material was used in the others. The shunt was then removed and the distal clamp released, followed in 1 minute by a gradual release of the proximal clamp. The defect in the aorta produced by the shunt was closed with a continuous over-and-over suture of No. 5-0 arterial silk and the subclavian artery ligated.

Animals were given penicillin postoperatively and followed clinically for changes in their pulses. Aortograms were done at intervals by taking films after injecting 10 cubic centimeters of 70 per cent urokon into the left ventricle. Groups were sacrificed at intervals for 18 months and the grafts studied grossly and histologically.

Tensile strength studies were done on the grafts at intervals up to 495 days. The nylon was dissected from the inner and outer fi-

TABLE I.—PHYSICAL CHARACTERISTICS OF NYLON WEAVE (NY-319 F)

	No.
Thread count, threads/in.	
Warp	254
Filler	126
Denier*	70
Weight, oz./sq. yd.	4.3
Thickness, inches	.007
Air porosity†	26.3

*Weight in grams of 9,000 meters of yarn.
†Number of cubic feet of air that will pass through a square foot of fabric at an air pressure of .5 inch of water.

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[1] Calendering is the process of pressing between heated rollers. Threads are flattened resulting in a decrease in thickness, lower porosity, and a smoother surface.

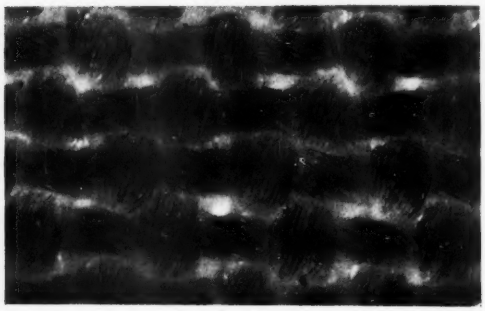

FIG. 1.

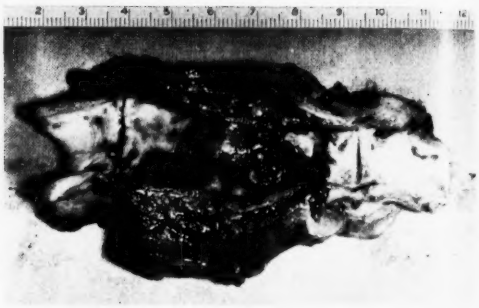

FIG. 3.

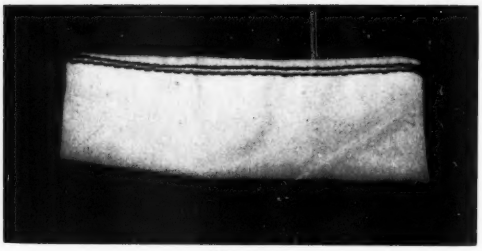

FIG. 2.

FIG. 4.

FIG. 1. Photomicrograph of nylon (NY-319F) weave. Note flattening of fibers due to calendering.

FIG. 2. Photograph of graft (nylon, NY-319F). Ends have been flamed to prevent raveling at time of insertion.

FIG. 3. Dog No. 171, 175 days, opened graft with surrounding encapsulated hematoma and thrombus occluding lumen.

FIG. 4. Dog No. 367, 13 days, opened graft showing loosely attached thrombi, one extending into lumen of distal aorta; this was not attached to sutures closing defect produced by shunt.

brous enclosures. Strips, ½ inch in width, were then cut in the direction of the fibers. Similar strips were prepared from the fabric from which the grafts were made to serve as controls. Thread counts were done and similar length specimens were used for both controls and fabrics making up the grafts. Tensile strength was then determined by the Instron apparatus.[2] Grafts made in the direction of the warp and filler were compared with respective controls. Similar determinations were made on grafts of another weave of nylon (517A) inserted into the abdominal aorta (Table II) for comparison.

[2]The Instron apparatus is a highly sensitive electronic weighing system employing bonded-wire strain gauges for detecting and recording the tensile load applied to the sample under test. A stress-strain curve is plotted. With this apparatus full scale sensitivities can be extended from 2 grams to 1,000 pounds or more. The accuracy is independent of the range and is better than 0.5 per cent.

RESULTS

The polyethylene shunts functioned satisfactorily, no animals developing postoperative paralysis or shock as a result of aortic occlusion during the period of insertion of the grafts. When the blood flow was restored, there was a minimal amount of blood loss through the interstices of the material which stopped completely after 1 to 3 minutes.

In 1 animal there was a loss of pulses at 3 months postoperatively. At autopsy a hematoma was found surrounding the graft with a thrombus in the distal portion completely occluding the lumen (Fig. 3). The remainder of the grafts remained patent during the period of observation.

The outer surface of the grafts became encapsulated by fibrous tissue which later

FIG. 5.

FIG. 5. Dog No. 158, 118 days, opened graft showing healed stage.

FIG. 6. Dog No. 152, 132 days, opened graft. New intima has covered only part of graft. Remainder covered by loosely attached, thick, fibrin layer with thrombus in central portion.

FIG. 7. Dog No. 140, 365 days, graft in situ. There is no evidence of dilatation.

grew through the interstices of the weave. The inner surface was initially covered by a fibrin lining 1 to 3 millimeters in thickness which was gradually replaced by a thin, glistening layer of fibrous tissue grossly resembling the intima of the adjacent artery (Fig. 5). This replacement was complete in part of the grafts at 3 to 4 months while not in others (Fig. 6).

In several of the grafts examined during the first 3 weeks there were loosely attached thrombi on the inner surface (Fig. 4). There were bare areas in others where these had become dislodged. In 1 animal, embolic occlusion of the left iliac artery resulted on the eleventh postoperative day.

The original tensile strength in pounds per 0.5 inch of the calendered nylon is 78.0 in the warp and 47.4 in the filler (Fig. 8). The decrease to 8.0 after 174 days represented a loss of 83 per cent of the original strength. After 365 days, there was 79 to 83 per cent and at 495 days 80 per cent loss (Fig. 8) (Table II).

The original tensile strength (lb./0.5 in.) of the nylon, 517A, inserted into the abdominal aorta was 48.0 in the warp and 22.0 in

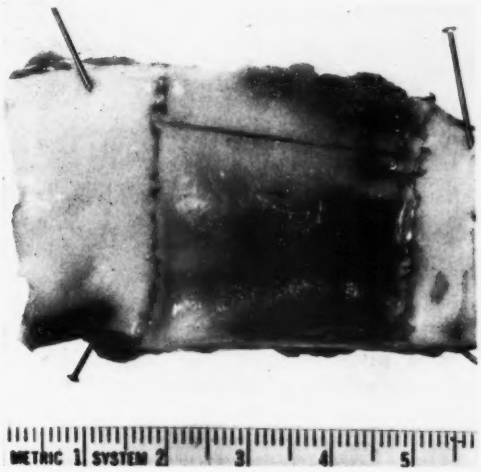

FIG. 6.

FIG. 7.

the filler. The decrease was 25 per cent in 89 days and an average of 78.1 per cent after 140 days (Table II). Further information regarding these grafts will be the subject of a later report.

Aneurysm or rupture of the grafts did not occur during the period of observation (Fig. 7). A group of animals are to be followed for longer periods for further evaluation.

DISCUSSION

The early results with the nylon grafts were satisfactory. This fact is not too sig-

TABLE II.—SUMMARY OF TENSILE STRENGTH DETERMINATIONS OF NYLON GRAFTS

Dog No.	*Type of nylon weave*	*No. of days*	*Tensile strength (lbs./0.5 in.)*				*Per cent strength lost*
			Control		*Grafts*		
			Warp	*Filler*	*Warp*	*Filler*	
492	517A	89	48.0	22.0		16.5	25
394	517A	140	48.0	22.0	8.0		83
268	517A	142	48.0	22.0	13.0		73
314	NY-319F	174	78.0	47.4		8.0	83
171	NY-319F	175	78.0	47.4		8.0	83
138	NY-319F	363	78.0	47.4		8.0	83
140	NY-319F	365	78.0	47.4		10.0	79
136	NY-319F	366	78.0	47.4		8.0	83
151	NY-319F	495	78.0	47.4		9.6	80

nificant when evaluating synthetic grafts in vessels this size, however, in that of a total of 82 grafts of nylon, dacron, orlon, ivalon, and teflon followed in this laboratory (2), there has been occlusion in only 1 instance.

The explanation of the cause of the loosely attached thrombi in some and delayed healing in others is not completely clear. Swelling of the nylon fibers after a short period of contact with the body fluids results in a marked diminution of the porosity of the grafts which might cause them to function more as solid tubes. In studies in this laboratory (3) it was found that nylon incited a considerable degree of tissue reaction. It is felt that either or both explanations might be causative factors. Technical errors cannot be excluded as a cause of thrombi, but are not deemed factors in delayed healing.

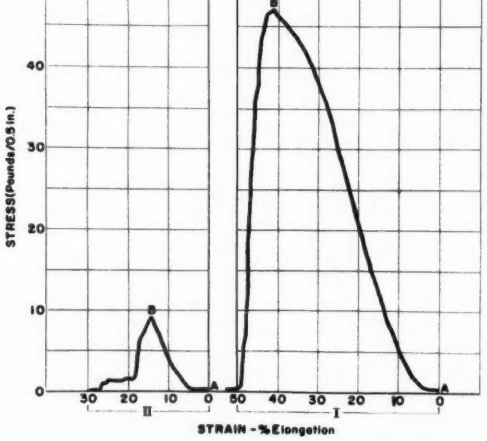

FIG. 8. Reproduction of Instron recording of tensile strength of nylon (Ny-319F). I, Control specimen (filler) ½ inch length, ½ inch width. II, Dog 151, 495 days (filler) ½ inch length, ½ inch width. Stress-strain curve in both I and II represented by line *A* to *B*. Specimen rupture at point *B*, or tensile strength.

The long term results with loss in strength are more significant. A plastic prosthesis serves as a network for the ingrowth of fibrous tissue. This tissue will add support, but it is doubtful that it will be sufficient to prevent aneurysm and rupture should the plastic itself break down. The synthetic material making up the grafts should, therefore, be strong enough to withstand the force of the blood stream and chemically inert to the point that this strength will be maintained over a long period of time. Nylon (polyhexamethylene adipamide) is strong enough, but it is far from being chemically inert. It is made by condensing hexamethylene diamine with adipic acid. Water is expelled upon polymerization. It is destroyed by strong acids and poorly resistant to weak acids, hydrolysis being rapid at a hydrogen ion concentration below 3. Alkaline solutions are hydrolytic at a hydrogen ion concentration above 8. At elevated temperatures, and, particularly, steam under pressure the breakdown is rapid. One would expect hydrolysis to occur when the material is subjected to the body fluids and slightly elevated temperatures over a long period of time.[3] Proteolytic enzymes might aid in the hydrolysis by attacking the amide group of the nylon polymer.

The loss in strength of nylon is thought to be due more to the chemical degradation

[3]In reviewing the technical literature one finds studies in which the synthetics have been subjected to various conditions for short periods of time. We were not, however, able to find instances in which they had been subjected to mild conditions for a prolonged period of time. The statements regarding the breakdown of nylon are, therefore, what one might expect in the body though no actual determinations have been made.

than the physical force to which it is subjected, as evidenced by an equal rate of loss of strength of the grafts in the abdominal and thoracic aortas, and those of a similar weave of nylon used in replacing defects in the pericardium.

A significant factor is the greatest loss of strength during the first 6 months with no further loss during the next year. The foreign body reaction incited by nylon gradually decreases during the first 6 months, and the fibers become enclosed in fibrous tissue. The degree of reaction and fibrosis parallel the rate of loss of strength. The fibers might be protected from further hydrolysis and breakdown by this fibrous tissue capsule. This is only theory, and, of course, further study will be necessary before definite conclusions can be drawn. If no further strength is lost, the remaining strength is adequate. Similar studies with other materials in the same period, particularly teflon, show much less loss of strength and will be the subject of later reports.

SUMMARY AND CONCLUSION

Calendered nylon grafts were inserted into the thoracic aorta of 28 dogs. The early results were satisfactory though there were loosely attached thrombi in several with dislodgment and embolic occlusion of the iliac artery in 1 instance.

After 6 months there is a loss of tensile strength of the nylon of 83 per cent and no change after a period of 495 days. No aneurysm or rupture of the grafts has occurred.

Further follow-up will be necessary to determine the ultimate outcome, but because the loss of strength of other synthetic materials, particularly teflon, is considerably less, it is believed that they are preferable to nylon as a vascular prosthesis.

REFERENCES

1. EDWARDS, W. S., and TAPP, J. S. Chemically treated nylon tubes used as arterial grafts. Surgery, 1955, 38: 61.
2. HARRISON, J. H. Synthetic materials as vascular prostheses: a comparative study in experimental animals. To be published.
3. HARRISON, J. H., SWANSON, D. S., and LINCOLN, A. F. A comparison of the tissue reaction to synthetic materials: dacron, ivalon sponge, nylon, orlon, and teflon. To be published.
4. SHUMACKER, H. B., JR., HARRIS, E. J., and SIDERYS, H. Pliable plastic tubes as aorta substitutes. Surgery, 1955, 37: 80.
5. VOORHEES, A. B., JR., JARETZKI, A., III, and BLAKEMORE, A. H. The use of tubes constructed from vinyon "N" cloth in bridging arterial defects. Ann Surg., 1952, 135: 332.

URINARY INCONTINENCE IN MYELOMENINGOCELES DUE TO A TETHERED SPINAL CORD AND ITS SURGICAL TREATMENT

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A VARIETY OF SURGICAL PROCEDURES for the treatment of urinary incontinence due to congenital defects in the lumbosacral area generally has met with failure. Urinary incontinence is a tremendous social, medical, and psychologic disability to the patient. It is troublesome, disagreeable, odoriferous, and uncomfortable, and it causes the patient to become a social outcast. We wish to present the histories of 5 patients with urinary incontinence since birth, who had had a myelomeningocele repair within the first few months of life. The spinal cord was found to be stretched under considerable tension and anchored in the sacrum. Following surgical release of the tethered cord, these patients have become continent for the first time in their lives. The ages of the patients ranged from 5 to 26 years.

As early as 1921, Chute observed a relationship between urinary retention and traction on the cauda equina by fibrous or fatty tissue. He stated that operations had been carried out in dissecting the scar tissue from the nervous tissue but that the results were not satisfactory although occasionally remarkable. However, only 1 of his patients was operated upon and the result was unsatisfactory. In 1930, Mertz and Smith reported 13 of their own cases and 26 cases from the literature of patients with urinary incontinence due to either pressure on the spinal cord or traction. Twelve patients were considered cured. However, in reviewing these cases it does not appear that any of them was actually of a traction phenomenon but all were due to compression. Penfield and Cone in 1932, in writing about spina bifida stated that "whether or not growth will bring about traction of the anchored spinal cord and its roots is difficult to say. If it does, a second operation might be carried out to free them." Cone, a number of years later in discussing the same problem, stated that the problem of fixation of the cord can be left to the ingenuity of the neurosurgeon. It would seem that they had considered the problem, but had not had any direct surgical experience with it. Meridith, in 1944, presented 2 cases of spina bifida occulta and a tethered cord but in neither was a myelomeningocele present.

In 1943, Browder reported 31 cases of lumbosacral anomalies in 17 of which operation was performed. Good results were obtained in 8 cases by freeing the spinal cord from its attachment. He was of the opinion that interference with the normal ascent of the cord led to an abnormal development and interference with the blood supply. The more distal the involvement of the cord, the better chance there was postoperatively for bladder improvement. From the report, one cannot ascertain how many of the patients had myelomeningoceles, lipomas, or spina bifida occulta. None had undergone previous spina bifida repairs with subsequent release of the tethered cord. Rather recently, Gross and his col-

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leagues reviewed 21 patients with urinary and fecal incontinence who had lumbosacral defects in the form of myelomeningoceles, meningoceles, or lipomas. In 16 previous repairs of the meningocele or myelomeningocele had been performed and in 2 lipomas had been removed from the cauda equina. They believed that relief of traction of the spinal cord offered improvement in but a few patients. No relief of urinary incontinence was achieved in the 2 patients with lipomas. Gross and his associates suggested that a wet colostomy, a sigmoid bladder, or even a skin ureterostomy be offered to afford relief to such patients.

From our review of the literature only a few patients with urinary incontinence due to tethered cord following repair of a myelomeningocele have been helped by surgical intervention. Not included in the present article are 4 other patients with urinary incontinence due to lipomas of the cauda equina causing a tense tethered cord.

CASE REPORTS

CASE 1. F. W., a 19 year old white male, was admitted to John Sealy Hospital in August 1954 because of urinary and fecal incontinence since birth. He had been born with a myelomeningocele which was repaired elsewhere at the age of 3 months. His head appeared large, so one might assume he had hydrocephalus which became arrested early in life. Mental development was above average. His lower extremities were atrophic and weak, causing him to walk with a waddle gait. He apparently had considerable weakness of his feet because as a youngster several arthrodeses of the ankle joints had been done. A saddle type of anesthesia was present with a diminished sensation of the fifth lumbar and first sacral dermatomes. Bladder infections had become rather frequent. He continually wore paper disposal pads about the perineum which had to be changed about every 2 hours because of the strong odor and soaking through of urine. When we first saw him, he had developed a pressure sore over one buttock due to the constant irritation of urine on an anesthetic area of skin. Roentgenograms of the lumbar spine showed a spina bifida occulta of the fifth lumbar and absence of bone of the posterior portion of the first 3 sacral segments. There was no urinary residuum and the bladder capacity varied from 300 to 400 cubic centimeters. Cystography revealed the presence of a cellular Christmas tree type of bladder. Excretory and retrograde urography showed relatively normal tracts. At cystoscopy, the bladder neck was elevated and voluntary efforts to void produced contraction of the trigone and depression of the bladder neck. Preoperative cystometrograms demonstrated involuntary voiding at a capacity of 200 cubic centimeters and straining to void at 450 cubic centimeters. Contractions were of variable vigor and predominantly hypertonic, and the typical resistance of the autonomous bladder to increasing increments of fluid was noted. The anal sphincter was completely flaccid. Proteus mirabilis was cultured from the urine. Novocain injected into the second, third, and fourth sacral foramina under x-ray visualization appeared to alleviate the incontinence to some degree for several hours. On September 14, 1954, a sacral exploration was carried out. The dural sac was under considerable tension and was just 2 centimeters below the surface of the skin surrounded by scar tissue at the site of the early myelomeningocele repair. After the dura was opened the spinal cord was seen in the sacrum and under extreme tension anchored to a mass of scar tissue at the distal portion of the sacrum. The nerve roots ran cephalad. Stimulation (square wave, 6 v., 3 millisec.) of the nerve roots did not cause any contraction of the bladder as recorded on the electric cystometrogram. The spinal cord and nerve roots were separated from the scar tissue by sharp dissection with the use of a stimulator in order to avoid cutting any functioning neural elements. Once the spinal cord was freed from its attachment, it was no longer under tension and advanced of its own accord 2 centimeters cephalad. The dura was closed and then separated from the dorsal scarring, and it also advanced cephalad about 2 centimeters.

This patient's postoperative course was most dramatic. After the first week, he remained continent most of the time. At the end of the second week, there was no nocturnal incontinence. During the first 6 months after operation he had episodes of incontinence during physical or emotional stress. He is now employed as a sports editor for his local newspaper and no longer wears any protective urinary devices. Most notable about the letters from his family is their delight in the absence of the urinary odors which pervaded their home. The patient carries no urinary residuum and the urine is not infected. Urograms now depict a normal upper urinary tract. Bladder capacity is over 500 cubic centimeters—the cystometrogram shows less resistance of the bladder to incremental filling. The first desire to void is noted at 350 cubic centimeters. The voiding pressure is strong and well maintained and the urinary stream is of good caliber and force and easily initiated. He maintains a schedule of voiding at 1½ to 2 hours, utilizes rectus assistance but no Credé, and is continent during the night. He is able to remain continent longer than 2 hours in the day, but this is the schedule we have placed him on.

CASE 2. S. T., a 5 year old girl, was first seen in our clinic in June of 1953 because of bladder and bowel

incontinence since birth. She was born with a myelomeningocele and at 3 weeks of age had been operated upon in another city. Her mental development was normal and there had been no enlargement of the head. She had had repeated urinary infections. The only abnormal neurologic finding was a saddle type of anesthesia. She had a weak anal sphincter but the proctologists believed it was strong enough for bowel training. The intravenous pyelogram revealed a bilateral hydronephrosis, and a retrograde urogram showed a dilated upper urinary tract, indicating a bladder neck obstruction of long standing. During the later part of 1953 and early 1954, her urinary residuum ranged from 2½ to 8 ounces—averaging 5 to 6 ounces. The bladder capacity was 250 cubic centimeters. Cystograms revealed a Christmas tree type of bladder. In March 1954, a transurethral resection was performed. Her residuum now averaged less than 2 ounces but she was still incontinent. Aerobacter aerogenes were cultured from her urine. The nonprotein nitrogen content was normal. She was admitted to the hospital in October 1954, with a progression of neurologic findings including some weakness of the right ankle. Roentgenograms revealed a spina bifida of the fifth lumbar and first sacral areas. On October 21, 1954, a lumbosacral exploration was carried out. The posterior wall of the sacrum was extremely thin and the dural sac was broadened and tense. When the dura was opened in the sacrum, the spinal cord was seen to be under extreme traction held by scar tissue at the distal portion of the dural sac and toward the right side. The arachnoid was thickened. On stimulation we were unable to obtain movements of the right toes, but could on the left. No bladder responses were obtained on the electric cystometrogram. The scar tissue was dissected free from active neural elements thereby allowing the cord to move cephalad several centimeters. The nerve roots at the level of the fifth lumbar and first sacral foramina left the cord in a cephalad fashion. Within 6 weeks after operation, the patient was continent during the day but incontinent at night. Her mother worked very hard on the problem of bladder training. The neurologic findings improved regarding the weakness of her right ankle, but the saddle anesthesia was unaltered. Variable but small urinary residuum was seen to exist from time to time and urinary infection with Aerobacter aerogenes persisted. Intravenous pyelograms showed no change.

As of June 1956, she has become completely continent. Recent cystograms still have not changed. There is still occasional nocturnal enuresis but sporadic in nature. A cystometrogram demonstrates an essentially autonomous bladder with poor accommodation to incremental filling but with a powerful voiding pressure. There has been 1 episode of clinical urinary infection in 1956, which was easily cared for with antibiotics. Despite the fact that a small urinary residuum still exists, it has been thought inappropriate to carry out further vesical neck resection at the present time in view of the fact that the child is now continent and no change has occurred in the upper urinary tract.

Case 3. P. A., a 14 year old Latin American male, had been incontinent of urine and feces since birth. At the age of 44 days, a myelomeningocele had been repaired elsewhere. His mother stated that he had voided frequently all his life and urinated 2 to 4 times a night. He complained of being wet all the time and that other children in school would not play with him because of the odor of urine. Psychologic testing revealed the boy to be a dull normal. The excretory urograms were normal in 1951. The first testing of his perineal sensation recorded was in 1953, and this was normal. The urinary residuum was 6 ounces with Staphylococcus aureus being cultured. The cystometrogram indicated a neurogenic bladder. A year later the perineal sensation was reported to be diminished to absent. The urinary residuum was 2 ounces. The intravenous pyelogram showed dilatation of the pelves and ureters. He had been having periodic suprapubic pain. On 4 subsequent examinations within 6 weeks, his urinary residuum ranged from 4½ to 16 ounces. In October 1954, a saddle type of anesthesia was present; and the patient was then admitted to the neurosurgical service. In addition to the saddle anesthesia there was some weakness of the right lower extremity. He was continually dribbling urine and his anal sphincter was lax. A cystometrogram showed a typical response of a spastic type of bladder with a poor reaction to increasing increments of fluid. He had a small bladder capacity, some sense of bladder distention, and with any abdominal contractions he would feel like urinating. Cystoscopy revealed cystitis, trabeculation, and gaping ureteral orifices. Roentgenograms of the lumbar and sacral spines showed a spina bifida of the sacrum and the fifth lumbar vertebra. Transsacral injections of procaine under x-ray control appeared to give the patient urinary continence for 3 to 4 hours. On October 22, 1954, a sacral exploration was carried out. The dural sac was encountered 1 centimeter beneath the surface of the skin over the sacrum. The spinal cord was anchored to a mass of scar tissue to the right side of the sacrum. The cord was thin and under considerable tension. All rootlets were stimulated, but the toes on the right side could not be made to move. There was no response on the cystometrogram. The rootlets took a cephalad course to their foramina of exit after leaving the spinal cord. The spinal cord was separated from the scar tissue by sharp dissection with the stimulator to avoid the division of any responsive neural tissue. After the spinal cord was released from the mass of scar tissue, the cord moved about 2 centimeters in a cephalad fashion. It no longer appeared under tension and lay on the anterior wall of the spinal canal. Postoperatively the urinary residuum dropped to less than 2 ounces. No change was noted in the gradual, progressive deterioration of the upper urinary tract. The family noted a marked diminution of odor of urine

about the boy and the home. In the ensuing months he has shown a definite improvement of continence of urine in the daytime. However, he wears a urinal when he goes out of the house. The cystogram shows a left ureteral reflux, but there is a significant improvement of the cystometric studies. His bladder capacity is at present about 230 cubic centimeters. He reacts more favorably to bladder filling, has a good voiding pressure, and with the use of abdominal pressure and Credé seems to pass a better stream. He is still incontinent at night, but with further training should improve during the daytime. The family and the patient believe that he is much more continent than before operation.

CASE 4. W. S., a 26 year old white male, was admitted to the neurosurgical service on January 8, 1955, with a history of urinary and occasional fecal incontinence since birth. At the age of 18 months, a myelomeningocele was repaired. The parents reported that their physician had told them that the myelomeningocele needed to be repaired at that time because of the development of hydrocephalus. However, his mental development progressed satisfactorily to where the patient had married and was able adequately to support himself and his wife as a salesman. Fifteen years ago a gracilis transplant to reinforce the urethral sphincter was done without any benefit. The left lower extremity was 3 centimeters shorter than the right and both legs were atrophic. His feet were small. All motions of both ankles were weak with a partial ankylosis of the joint. Abduction of the hips was somewhat impaired. The rectal sphincter had a weak voluntary contraction. There was a saddle type of anesthesia with extension down the posterior aspect of both lower extremities to the heel. On the right, the anesthesia extended also along the lateral aspect of the leg to the lateral aspect of the foot. The ankle reflexes were bilaterally absent. Roentgenograms of the lumbosacral spine revealed the presence of a spina bifida. Roentgenograms of the skull suggested the possibility of a platybasia. He had no children although he did have satisfactory sexual relationship, including ejaculation.

The bladder functional type was of a good capacity with a certain amount of sensation, a poor expulsive force, and poor sphincteric tone resulting in constant dribbling. There was no urinary residuum. The excretory urogram was normal. The cystometrogram revealed a capacity of about 400 cubic centimeters with poor voluntary contractions. Procaine was injected through the sacral foramina under x-ray visualization causing no effect on the incontinence. Proteus was cultured from the urine.

On January 27, 1955, a lumbosacral exploration was carried out. The spinous process and lamina of the fifth lumbar vertebra and the posterior arch of the sacrum were absent. The dural sac appeared to be under traction and adhered to a mass of scar tissue and some fat. After the dura was opened the spinal cord was found to be extending into the sacrum under severe tension being attached distally to scar tissue. On stimulation of the nerve roots, there was no bladder response as indicated on the electric cystometrogram. The nerve roots left the cord and ran cephalad to their foramina. The spinal cord was divided from the scar tissue and this caused the cord to move cephalad about 2 centimeters. It was no longer under traction and lay on the anterior surface of the spinal canal. On the tenth postoperative day, he developed a spinal fluid leak from the wound, which subsided after 2 weeks leaving a new false meningocele. Postoperatively, there was a gradual decrease in incontinence. His ability to maintain control has progressed to the point of complete continence both day and night with loss of control occurring only in the presence of an emotional situation. There is no odor of urine about the house, which preoperatively was most prominent. There have been no clinical urinary infections.

CASE 5. R. N., a 13 year old white male with urinary and fecal incontinence since birth, was admitted to the neurosurgical service on September 15, 1955. He was born with a myelomeningocele which the parents stated did not have any covering and gradually healed over with scar tissue. Previously, a gracilis muscle transplant to the anus had been done with good results for only a year postoperatively. His head appeared to be somewhat larger than normal. The gait was wide and waddling because of weakness of his lower extremities which necessitated a foot brace on the right. There was a saddle type of anesthesia with extension bilaterally to the posterior aspect of the lower extremities down to the heels. The knee reflexes were present but both ankle jerks were absent. Quadriceps movement bilaterally was only fair while the hamstrings were poor on the right and fair on the left. Dorsiflexion of the ankle was impaired, and toe movements were absent. Roentgenograms revealed a spina bifida of the fourth and fifth lumbar vertebrae. Psychologic studies showed the patient to be in the borderline normal range. The bladder capacity was small. The cystogram showed a Christmas tree type of bladder with reflux up the left ureter. The intravenous pyelogram was essentially normal with the exception of very mild dilatation of the juxtavesical ureters. The vesical functional type was that of dribbling with any body movement. At rest, continence might exist for as much as an hour with subsequent autonomous evacuation. No sensation of bladder fullness or awareness of urine dribbling was noted. The bladder capacity was about 3 ounces, with poor tone, and no sensation. Cystoscopy revealed contracture of the vesical neck. The myelogram was rather bizarre suggesting possibly an adhesive arachnoiditis.

On September 22, 1956, a lumbosacral exploration was performed. The dural sac was adherent to a mass of scar tissue just a half a centimeter below the surface of the skin over the sacrum and under considerable traction. After the dura was opened, the spinal cord

was seen to be thinned and under severe tension anchoring itself distally to the scar tissue. The arachnoid was scarred down to the pia obliterating the subarachnoid space in many areas visualized. Stimulation of the nerve roots did not produce any contraction of the bladder as recorded on the electric cystometrogram. The nerve roots ran cephalad. The spinal cord was dissected free from the scar tissue and then spontaneously moved cephalad about 2 centimeters finally lying on the anterior wall of the spinal canal. On October 10, 1955, a transurethral resection was done.

Postoperatively, the bladder capacity increased from 3 to 4 ounces to 10. There was no other vesical change, except a lack of residuum. In the relatively short postoperative period there has been gradual increase in continence, definitely noticeable by the patient and his father. The distasteful odor of urine has perceptibly diminished. With training and a voiding schedule, he is much drier but is not totally continent. The cystometrogram reveals an increase in bladder capacity and an improved reaction to incremental filling. One rather unusual factor has been the ability of the boy to remain dry at night with increasing regularity.

DISCUSSION

Previous surgical attacks for urinary incontinence in patients with repaired myelomeningoceles generally have not been successful. Alexander and his group reported in 1954 a single patient similar to ours. Although the spinal cord was tethered at the sacrum, there was no tension, and stimulation of the third sacral nerve root caused bladder contractions. The incontinence was thought to be due to a marked hypotonia of the detrusor with contractile hyperactivity of segmental character. Following surgical division of the third sacral nerve bilaterally, their patient became almost continent at the end of a month. The hyperactive segmental contractions were completely abolished by the division of the third sacral nerve permitting an integrated contraction of the detrusor muscle as a whole.

Alexander's explanation does not seem tenable to us because in the presence of a saddle type of anesthesia, there was a reaction to the stimulation of the third sacral nerve suggesting the presence of preganglionic parasympathetic fibers in this nerve. A complete reflex arc could only exist if it included visceral afferent fibers reaching the spinal cord at the level of the twelfth thoracic and first lumbar vertebrae, then through an intrasegmental fasciculus proprius of the cord since the presence of the saddle anesthesia indicated destruction of the dorsal roots at the level of the third sacral nerve.

On the basis that the second, third, and fourth sacral nerves contribute fibers to the bladder with the largest coming from the third sacral, Heimberger and his associates, in 1948, carried out bilateral novocain blocks of the third sacral nerve in 8 patients with traumatic paraplegia causing marked relaxation of the detrusor muscle in 7 and slight in 1. They also performed a number of blocks of the second, third, and fourth sacral nerves in various combinations. Their conclusion was that the third sacral nerve is the predominant sacral nerve supply to the human bladder. A sphincter reflex separate from that controlling the detrusor exists whereby the sphincter tone may be diminished more markedly after blocking one pair of nerves, while the detrusor is more markedly relaxed by blocking a different pair of nerve roots. Meirowsky, in 1950, stated that surgical elimination of the sacral impulses in the traumatic paraplegic is an essential factor in the production of bladder automatism and that the bladder possesses a functional mechanism of its own. This observation has been verified by us as well as others in the use of intrathecal alcohol and cordectomy in traumatic paraplegics to improve bladder function.

However, our 5 patients and Alexander's 1 differ from those with traumatic paraplegia, in whom the sacral reflex was intact but physiologically disconnected within the spinal cord at the site of injury. This difference would seem to us to be that the reflex arc is already destroyed and, therefore, division of the third sacral nerve itself would be of no avail.

Morales and his co-workers, in 1956, reported 31 cases of lumbosacral spina bifidas and unsatisfactory urinary control in children. These patients voided by overflow. The authors believed that bladder training

programs, laminectomies, or sphincter operations were of no value. Transurethral resection helped some of the children while urinary diversion procedures were more satisfactory. They disagreed with the opinion of others that bladder disturbances in spina bifida patients were comparable to those in traumatic paraplegic. Any activity in the detrusor muscle and internal sphincter must apparently occur as the result of impulses transmitted through a reflex arc that lies wholly within the vesical wall—autonomous bladder. They concluded that the incontinence in the patient with a spina bifida was due to flaccid urinary leakage increased by bodily movements, which is not common in the traumatic paraplegic.

Nevertheless, on the basis of the case report of Alexander we elected to operate upon our first patient. All our patients had had a previously repaired myelomeningocele, urinary incontinence since birth, and a saddle type of anesthesia, and, most important of all, severe traction of the tethered spinal cord. We were unable to elicit any bladder contraction from stimulating the spinal cord in the lumbar and sacral areas, and the lower lumbar and all the sacral nerve roots (square wave, 6 v., 3 millisec.). A striking finding was the severe degree of traction on the spinal cord which was absent in Alexander's patient. After dividing the spinal cord and nerve rootlets from the scar tissue at a site where there was no response to stimulation, the spinal cord was no longer under traction and spontaneously moved cephalad several centimeters. The patients soon developed continence in varying degrees. This is not an autonomic bladder, but one with voluntary control. The patients postoperatively can, at will, start and stop their urinary stream. Sensation to void was present but of a different nature than in the normal individual. By virtue of the fact that the patient had a saddle type of anesthesia, the sacral reflex arc had obviously been destroyed before our surgery. Therefore, the previous work by others in which the division of the third sacral nerve root resulted in an improved bladder function most likely does not play a role in producing continence in our patients. The emotional factor in continence is very prominent. Several patients became incontinent postoperatively when under tension and anxiety and yet while asleep remained continent though all had had nocturnal incontinence preoperatively.

It appears that the bladders in our 5 patients had been totally denervated before the untethering of the spinal cord with the exception of the sympathetic innervation which arises from the lowered thoracic spinal cord. It is generally conceded that the sympathetic nervous system plays little or no role in normal micturition. However, it might be feasible to entertain the possibility that severe traction of the tethered spinal cord interferes with the thoracic outflow of sympathetic fibers. With the release of tension the role of such sympathetic fibers may become more prominent in micturition. We believe that this has occurred as a result of decreasing local segmental contractions, and perhaps hyperirritability of the detrusor, and by increasing the peripheral resistance to urination. This reaction is based upon the fact that the bladder capacity has enlarged and continence has followed release of the tethered tense spinal cord. The tethering alone does not appear to be responsible but rather is in addition to the acute stretching under severe tension.

SUMMARY

Five cases of urinary incontinence in patients with a tense tethered spinal cord anchored to the sacrum by scar tissue, previously repaired myelomeningoceles, saddle type of anesthesia, and abnormal neurologic findings in the lower extremities are presented. Varying degrees of continence occurred following release of the tense tethered spinal cord from the scar tissue in the sacrum. The bladders were totally denervated except for the sympathetic supply, which may play a more prominent role in micturition than previously described.

REFERENCES

1. Alexander, E., Garvey, F. K., and Boyce, W. Congenital lumbosacral myelomeningocele with incontinence. J. Neurosurg., 1954, 11: 183–191.
2. Browder, J. The surgical treatment of the congenital malformations implicating the distal spinal cord. Ann. Surg., 1943, 117: 118–133.
3. Chute, A. L. The relation between spina bifida occulta in certain cases of retention. J. Urol., Balt., 1921, 5: 317–324.
4. Cone, W. Spina bifidum and cranium bifidum. In: Christopher's Textbook of Surgery. P. 435. Philadelphia: W. B. Saunders Co., 1943.
5. Gross, R. E., Holcomb, G. W., and Swan, H. Treatment of neurogenic urinary and fecal incontinence in children. Arch. Surg., 1953, 66: 143–154.
6. Heimberger, R. F., Freeman, L. W., and Wilde, N. J. Sacral nerve innervation of the human bladder. J. Neurosurg., 1948, 5: 154–164.
7. Meirowsky, A. M., Scheibert, C. D., and Hinchey, T. R. Bladder automaticity after rhizotomy. J. Neurosurg., 1950, 7: 33–38.
8. Meridith, J. M. Unusual congenital anomalies of the lumbosacral spine (spina bifida); with a report of 3 cases. J. Nerv. Ment. Dis., 1944, 99: 115–133.
9. Mertz, H. O., and Smith, L. A. Posterior spinal fusion defects and nerve dysfunction of the urinary tract. J. Urol., Balt., 1930, 24: 41–82.
10. Morales, P. A., Deaver, G. G., and Hotchkiss, R. S. Urological complications of spina bifida in children. J. Urol., Balt., 1956, 73: 537–550.
11. Penfield, W., and Cone, W. Spina bifidum and cranium bifidum. J. Am. M. Ass., 1932, 98: 454–460.

A TWENTY YEAR FOLLOW-UP IN FIFTY BELOW KNEE AMPUTATIONS FOR GANGRENE IN DIABETICS

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MORTALITY AND MORBIDITY following amputations for infection and gangrene in diabetic patients have been reduced since 1920 by diet, insulin, antibiotics, improved anesthesia, transfusions, correction of electrolytic balances, education by organized clinics in methods of foot care followed by frequent periodic observations and improved surgical techniques. Degenerative arterial disease, however, continues to occur in this group of individuals at an earlier age than in nondiabetics. Many types of dietary treatment have been advocated. At present the necessity for the absolute control of blood sugar is under intimate scrutiny. The role of the midbrain, hypophysis, and endocrine organs, besides the pancreas, is being experimentally surveyed. The result of intensified interest and patient education has been to reduce vascular complications in younger people, but the inevitable arteriosclerotic process associated with diabetes has been only somewhat delayed in appearance and its inevitability remains unsolved.

In this series of 50 amputations for gangrene in patients with diabetes mellitus there were 20 males and 30 females distributed by age as follows: 6 (12 per cent) were 40 to 50 years old; 13 (26 per cent) 50 to 60; 22 (44 per cent) 60 to 70; 8 (16 per cent) 70 to 80; and 1 (2 per cent) 80 to 90 years.

The mortality following amputations, most of which were through the thigh, for gangrene in the lower extremities of diabetics prior to 1930 varied from 40 to 90 per cent in the metropolitan New York area. Thigh amputees rarely returned to gainful occupation. Most of them led a sedentary chair-bed life and required the nursing care of a family member. In many instances this situation decreased the earning capacity of the family to an indigent level, necessitating governmental financial relief. Of the thigh amputees of this period at Presbyterian Hospital, only about 10 per cent acquired and wore a prosthesis. Thirty-two (72 per cent) of 44 surviving amputees in this series of 50 amputations below the knee wore prostheses regularly. Their age distribution was as follows: 3 were 40 to 50 years old, 8 were 50 to 60; 15 were 60 to 70; 6 were 70 to 80. Prostheses were not worn by some for financial reasons or preference for chair existence. An additional 4 patients, 9 per cent, had stumps suitable for prostheses and could have worn them, making a total of 81.8 per cent of patients who could have worn prostheses. Of 12 patients with bilateral amputations, 5 or 48 per cent, wore prostheses on both legs. Of these, 2 were between 40 and 50 years old, 1 was between 60 and 70, and 2 were between 70 and 80.

The economic and family environment in the city and the methods of living and transportation are more difficult than in the country so that the ability to attend clinics regularly was almost impossible. Patients were overwhelmed by these difficulties, disintegrated rapidly, and died in a relatively short time after amputation. The textbook teachings of this era indicated a thigh amputation as the proper treatment in these cases. It became deeply ingrained, widely disseminated, and was almost universally practiced because below knee amputations had been so frequently followed by a thigh amputation and a fatality.

The obvious reduction of complications in clinics which practiced prophylactic foot care stimulated interest in methods of reducing morbidity and mortality. In 1930, at the Presbyterian Hospital in New York,

TABLE I.—BILATERAL AMPUTATION

Case No.	Amputation		Longevity	
	First	*Second*	*After first*	*After second*
1	True guillotine 1–9–29 left	Mod. guillotine 10–4–30 right	12 years, 6 months	11 years, 9 months
2	Mod. guillotine 10–16–39 left	Mod. guillotine 12–5–39 right	2 months	12 days
3	Mod. guillotine 1–30–31 right	Mod. guillotine 7–6–33 left	2 years, 10 months	3 months
4	Gritti Stokes 8–23–33 left	Mod. guillotine 5–29–34 right	10 years, 2 months	9 years, 5 months
5	Mod. guillotine 8–19–33 left	Mod. guillotine 3–7–36 right	12 years	9 years
6	Mod. guillotine 1–30–37 right	Mod. guillotine 1–9–40 left	4 years, 3 months	1 year, 3 months
7	Mod. guillotine 3–24–44 left	Mod. guillotine 2–26–51 right	10 years, 5 months	3 years, 6 months
8	Mod. guillotine 12–18–45 right	Mod. guillotine 3–19–47 left	9 years	7 years
9	Flap amputation 5–26–39 left	Mod. guillotine 12–11–40 right	5 years, 6 months	4 years
10	Thigh lower third 1928 right	Mod. guillotine 2–12–32 left	9 years	5 years
11	True guillotine 7–23–30 right	Mod. guillotine 3–27–31 left	4 years, 5 months	3 years, 9 months
12	Thigh lower third 4–29–40	Mod. guillotine 9–14–40	2 years, 7 months	2 years, 2 months

12 of 50 amputations were bilateral—24 per cent.
Average longevity after first amputation—7.6 years.
Average longevity after second amputation—4.7 years.

after reviewing our depressing statistics previous to this date, I began to search for a method to amputate gangrenous extremities below the knee, and in 1933 published in the August issue of the *Archives of Surgery* a technique which for lack of better nomenclature was called a modified guillotine amputation below the knee for gangrene of the extremity in diabetics and arteriosclerotics. This technique has been used since 1930 in practically all cases of this type which I have encountered, provided the pathologic condition did not extend so close to the knee as to make the remaining tissues useless for a prosthesis below the knee or provided the disease in the knee joint itself did not preclude the use of an artificial limb.

The surgical procedures of incision and drainage require an intimate anatomic knowledge of the foot, a dedication to meticulous and gentle surgical principles, and an evaluation of the degree of surgery that the local blood supply will tolerate. Single and multiple toe amputations may precipitate higher amputations as life-saving emergencies. I have applied the same surgical principles to toe amputations that have been used in the modified guillotine technique in the leg. Transmetatarsal amputation introduced by McKittrick has earned a useful place as a definitive surgical treatment in a carefully selected group of these cases. Amputations through the tarsus and ankle joint have not proved useful over the years.

A true guillotine amputation through the lower third of the leg is a very useful and often a life-saving procedure. Its usefulness seems to have been forgotten, and it is seldom done but is frequently indicated in septic cases. It should never be abandoned but should be thought of in each case, particularly in the presence of fulminating infection in an uncontrolled diabetic. No attempt should be made to invade soft parts for closure or plastic repair at operation. A quick absolute guillotine procedure removes the patient from infection and facilitates subsequent control of the diabetes.

Many types of flap operations of the leg have been used, but subsequent necrosis brought this procedure into disrepute because of the many secondary thigh amputations in depleted patients which resulted in an almost prohibitive operative mortality.

Knee disarticulations were modified to the Gritti-Stokes procedure followed by the Callander technique, but both of these operations removed the knee joint and, in a small percentage, local necrosis necessitated a thigh amputation. So the supracondylar thigh amputation came to be the accepted therapy in these gangrenous cases and was taught in medical schools and surgical texts. In this series there were 12 bilateral amputations, 1 or both of which were below the knee (Table I).

A below the knee amputation was primarily conceived in an attempt to preserve the functions of this joint. There has been universal and complete agreement among bilateral amputees encountered that, if one procedure was through the thigh, the other below the knee, and both stumps were healed, they invariably preferred the limb in which the knee joint was present. This has been an incentive to the continuous salvage of the knee joint. There were 3 reamputations (6.8 per cent) in this series of 44 patients who survived this amputation described as follows:

1. Bilateral—right modified guillotine on November 22, 1934; right thigh on December 26, 1934; left thigh on February 11, 1935. Patient was depleted; necrosis of stump.

2. Unilateral—modified guillotine on December 10, 1932, followed amputation of toe on December 3, 1932. Patient had gas gangrene.

3. Unilateral—modified guillotine on January 9, 1940; on April 22, 1941 he had reamputation through lower third of thigh.

The problem in amputations below the knee has primarily concerned technically traumatizing soft tissues with diminished arterial blood supply in the presence of proliferating infection in soft parts, bones, joints, tendon sheaths, lymphatics, and veins in a depleted patient, physiologically older than his chronologic age, with diffuse occlusive arterial disease of the brain, retina, heart, and kidneys, and a diminished ability in the presence of hyperglycemia to combat infection. An abstract view of this clinical entity exposes the elements of a high morbidity and mortality. In the presence of occluded main arteries the viability of the part is largely concerned with the preservation of existing collateral arterial blood supply. Amputation, to be successful, must preserve this collateral of the amputation site for, if destroyed, necrosis is inevitable. With these principles in mind, the procedure becomes ritualistic.

PROCEDURE

Preoperatively adequate hydration, electrolyte balance, blood volume, judicious sedation, such control of diabetes as is possible, and adequate proper antibiotic therapy are established.

The extremity is prepared in the operating room by the operator as follows: (1) It is carefully shaved as skin cuts often become infected and delay primary healing. (2) The operative area is gently cleansed with ether, alcohol, and a 2 to 5 per cent solution of tincture of iodine by gentle stroking or pouring on of the solution because hard rubbing massage of potentially infected lymphatics may cause bacteria to be transported from the infected part below to the amputation site where subsequent infection may occur. Tincture of iodine is poured over the infected area and it is widely encased in 2 sterile towels.

Anesthesia is begun after the extremity has been prepared in order to diminish anesthetic time. A minimum of anesthetic, suited to the particular patient, is indicated and supplemented by a generous inhalation of oxygen to maintain adequate oxygenated blood. There is no anesthetic of choice—it must be chosen as best suiting the patient, combined with the capabilities of the available anesthetist. The operation should be conducted to shorten the anesthesia as much as possible without traumatizing speed.

Small mosquito clamps, No. 4-0 or 5-0 silk ligatures, small curved and straight needles, small and medium retractors, Gigli saws, rongeurs, double action bone cutting forceps, an ordinary scalpel, medium curved scissors, and a long amputation knife constitute the major instruments. Note the absence

of any tissue or skin grasping forceps; these instruments may be present but are used minimally and never on the skin. Skin necrosis at grasped skin areas may initiate infection which will prolong or defeat local healing.

The skin incision is begun 12 to 15 centimeters below the anterior tibial tubercle at the middle of the anterior medial surface of the tibia and extended distally for 4 to 6 inches. The fascia at each side of the tibia is incised, the finger or a periosteal elevator is inserted and the investing muscles of each side are swept away from the tibia in an avascular plane immediately adjacent to the tibia posteriorly to the interosseous membrane for the entire length of the wound. The interosseous membrane is pierced with a sharp periosteal elevator and separated from the tibia. The tibia has now been separated from all surrounding soft parts without having entered the muscles. A Gigli saw is passed beneath the tibia at the upper end of the wound. The soft parts are protected from the saw by medium abdominal retractors. The tibia is divided as water is dripped upon the area. The lower tibia is now lifted forward out of the wound with a bone hook. The most difficult and probably most traumatizing step of the procedure follows, namely the division of the fibula. This bone is deeply seated as approached through this wound and is surrounded by large muscle bellies laterally, even in thin extremities. It is palpated most superficially in the lower portion of the wound and is exposed with gentle retraction. The fascia is incised medially for a centimeter at the periosteum, care being taken to avoid injury to the peroneal vessels posteriorly and medially, and through this cleared small area the fibula is divided well below the tibia with a double action bone cutting forcep. This may be somewhat difficult and an attempt is made not to splinter the fibula. After division of the fibula, the foot and lower leg can be brought to a right angle with the upper leg. The severed bone ends protrude. The tibia is free of soft parts but muscles must be removed from the fibula to the extent of the wound with a curved scissors whose points are directed toward the periosteum. No periosteum should be removed with the soft parts, and the peroneal vessels should be watched for and avoided, this is important. Both bones now have been divested of soft parts and protrude from the wound. With the lower fragment held at right angle to the upper fragment a circular skin incision is then made medially and laterally from the lower end of the longitudinal skin incision including the subcutaneous tissue and deep fascia in one layer. Veins are grasped with mosquito forceps without surrounding tissue and ligated with No. 5-0 silk. The skin and fascia flap is dissected off the muscles upward in an avascular plane for 2 or 3 centimeters. The soft parts are then divided as follows: A towel is placed around the upper skin flap, everting it, exposing the muscle. Traction is made on the exposed bone ends and heel with the specimen held at right angles to the leg. The assistant's hand is used as a tourniquet. A long amputation knife is placed adjacent to the site where the skin fascia flap is still attached to the muscle and with a pulling motion toward the operator—not a sawing motion—the muscles are completely divided at right angles. Hemostasis of principal arteries, veins, and bleeding muscle branches is accomplished by grasping them individually with a mosquito forceps and ligating them with as fine a silk as will stand the tension of tying. Hemostasis must be accurate and complete. Ooze must be ligated if persistent. The protruding end of the fibula is then grasped and its investing muscles are excised from the periosteum with scissors, care being taken again to avoid the peroneal vessels. This dissection is carried upward for 1 to 2 centimeters proximal to the end of the tibia. The fibula is reamputated with the double action bone cutting forceps placed from the lateral side 1 to 2 centimeters above the tibia. Adequate gentle soft part retraction is necessary with an abdominal retractor for protection and to see

possible bleeders high up in the wound. If present, they must be ligated. The posterior tibial nerve is next grasped and dissected upward above the tibial end, injected with ½ to 1 cubic centimeter of 1 per cent novocain, followed by a similar amount of 95 per cent absolute alcohol through a thin needle entirely within the nerve so that no fluid escapes into the soft parts. The nerve is ligated with fine silk, gently pulled downward, and slowly divided with a knife. If the ligature has not secured a frequent large sized artery in the nerve, it is caught and ligated as the nerve is divided. This vessel frequently spurts and if it retracts in the wound after division of the nerve, its exposure and ligation may be quite locally traumatizing. The nerve retracts upward into the soft parts above the end of the tibia. The other nerves usually do not require such treatment. The sharp anterior edge of the tibia is rongeured off without entering the marrow cavity. The wound is copiously washed with 1 to 2 quarts of fresh sterile saline solution. Hemostasis is reviewed and completed. If not complete and tissue trauma is suspected, a small soft rubber drain is placed posterior to the tibial stump and possibly also to the area of the fibula. Usually 1 drain suffices. A small safety pin is placed on the end of the drain and a heavy silk ligature is tied to the pin and brought out of the dressing so that the drain can be removed without disturbing the stump and disarranging the healing tissues before they become too firmly healed to separate. The wound is closed by suturing the deep fascia throughout the wound with interrupted No. 4-0 or 5-0 silk on a small cutting edge needle, unless there is undue tension, in which event only the skin is sutured. Skin closure is important; the skin is not touched with a tissue forceps but grasped in gauze and held, as No. 5-0 silk interrupted sutures on a fine cutting edge needle are placed and tied just approximating the everted edge and without protruding bits of subcutaneous tissue through the suture line. Skin approximation must be exact, complete, and done with the minimum of trauma.

The dressing is important and is placed as follows: A piece of vaseline gauze is placed against the skin posteriorly, a small strip is placed over the suture line, and a large number of fluffed large compresses are placed over the stump to the knee. If the wound has been drained, the ligature attached to the drain is brought out of the end of the dressing and left as a means to remove the drain in 24 to 48 hours. A piece of moleskin adhesive, the size of the posterior surface of the thigh, is placed several inches above the knee, above the dressing against the skin of the thigh and distally against the fluffed compresses and a large pad. Its distal end is cut and folded to about 1 inch width and protrudes about 4 inches beyond the dressing. This, with the compresses, is incorporated snugly in 2 gauze rolls. A 2 inch adhesive strip is placed from the skin of the thigh laterally around the end of the dressing to a similar area medially. Several strips of adhesive partially encircle the dressing at several areas. The entire dressing is encased in a towel which is held with safety pins. The moleskin adhesive straps extending beyond the dressing can be used to pick up the stump and move it, and to it is attached a 2 pound weight by a small rope which is led through a small single pulley attached to the foot of the bed. This procedure steadies the stump, relieves muscle spasm, and keeps the knee extended. This dressing is comfortable. It is sufficiently copious to prevent soiling of wound from excreta. It remains in place until the stump is healed and ready for an ace bandage shrinker.

The sutures are removed 10 to 14 days later unless there are indications for their earlier removal.

The dressing is cut down anteriorly over the stump and turned back with sterile instruments to expose the suture line. It is replaced with fresh gauze over the stump after inspection or suture removal and held with adhesive strips. In this way tissue relationships of the stump remain undisturbed

during a 14 to 20 day healing period thereby preventing accumulation of serum or oozing into the wound, both of which are conducive to infection from organisms in the lymphatics which were draining the infected amputated area. The white blood count and blood sugar should be followed beginning the second or third day, either daily or each second day. Should these, the pulse, or temperature not trend toward or become normal by the fourth or fifth day, the wound is inspected and treated as indicated. If drained, the drain is removed without opening the dressing except possibly enough to allow its exit on the second or third day. In this way removal of the drain does not disturb tissue approximation. If a dressing is too small, uncomfortable, is removed by an unco-operative patient, or comes off, the wound almost invariably becomes infected and the purpose of the procedure is defeated.

As soon as his condition warrants, the patient is allowed to be up in a chair with the dressing intact without the traction in place. The dressing is replaced about the fourteenth day with a snug ace bandage to above the knee. No pillows are allowed under the stump because knee contracture must be prevented. Patients are given crutches as soon as they are strong enough to use them. Many are too feeble or have too profound arteriosclerotic disease elsewhere to use crutches. No pylon prostheses are used. The stump is kept in a shrinker for 3 or 4 months, exercising the knee joint at regular intervals, and is usually ready for an artificial leg at that time. Weight is distributed by a thigh cuff and weight-bearing areas beneath the medial tibial condyle and the area just below the fibular head. As the stump shrinks the socket is padded and adjusted. Close supervision is practiced to prevent pressure areas until the patient becomes used to the prosthesis.

DISCUSSION

In this series of 50 below the knee amputations, 6 patients (12 per cent) died in the hospital, yielding a mortality of 12 per cent. A brief summary of these 6 cases follows:

1. The patient lived 4 days; was in extremis at amputation; should not have been operated upon. A true guillotine amputation would have been better.
2. The patient lived 2 months after amputation; died 4 days after amputation of toe of other foot, of hyperpyrexia of unknown origin.
3. The patient lived 35 days after amputation, was disoriented, pulled dressings off, and picked wound open during night.
4. The patient lived 8 days after amputation; died in sleep of encephalomalacia.
5. The patient died 48 hours after amputation. Postmortem did not show cause of death. Brain not examined.
6. The patient died 3 days after amputation, of sepsis.

In this series of 50 cases the longevity of the 44 patients surviving below the knee amputations was as follows: 5 patients, 12 per cent, lived less than 1 year; 17, 40 per cent, lived 1 to 5 years; 9, 22 per cent, lived 5 to 10 years; 6, 14 per cent, lived 10 to 15 years; 5, 12 per cent, lived over 15 years and are still living; 6 died in the hospital; and 2 were lost to follow-up during the first year. The fact that 5, or 12 per cent, are surviving and walking on prostheses 15 years or longer after operation constitutes sufficient encouragement to continue the use of this type of amputation when indicated in diabetics.

CONCLUSION

In a group of 50 diabetics with below the knee amputations by the technique described, the average survival was 5½ years and 81.2 per cent of the stumps were suitable for prostheses. The large number rehabilitated to full or part time work, the mortality of 12 per cent (which should be improved with more careful selection of cases), the reamputation rate of 6 per cent, and the 42 per cent of bilateral amputees using artificial legs constitute factors sufficiently encouraging to warrant the abolition from textbooks and teaching institutions of the doctrine that thigh amputation is the method of choice in such patients.

THE TREATMENT OF LYMPHOPATHIA VENEREUM STRICTURES OF THE RECTUM BY THE ABDOMINOPERINEAL PULL-THROUGH PROCEDURE

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LYMPHOPATHIA VENEREUM (lymphogranuloma inguinale) is a venereal disease involving the lymphatics of the genital and anal region. It is caused by a filterable virus which is usually transmitted during sexual intercourse. It is more common in the negro race. In 380 cases studied at Bellevue Hospital in New York City, 73 per cent were in negroes and 72 per cent were in males. Whereas the usual result in the male is an inguinal lymphadenitis, in the female the lymph drainage is into the perirectal lymphatics resulting in the production of an inflammatory rectal stricture. Sometimes the entire colon is involved. Perirectal abscesses and anal fistulas may be present. Perirectal involvement may also occur in the male but is relatively uncommon. Constitutional symptoms such as fever, malaise, nausea, and vomiting are often present. Fatalities are uncommon from the disease itself. Elephantiasis of the scrotum, penis, and vulva may result. Ninety-five per cent of patients will react positively to the intradermal injection of an antigen made from material infected with lymphopathia venereum virus (Frei test).

Gratifying results have been reported with a decreasing number of rectal complications following the use of broad spectrum antibiotics such as aureomycin, chloramphenicol, and terramycin in early cases. Control of secondary infection, rather than an effect on the primary organism, may be the important factor in the improved results. When there is resistance to one antibiotic, another may be tried. The advanced cases still remain a problem though with the present use of antibiotics this complication may be greatly decreased in the future.

Rectal dilatations, which have long been used in combatting strictures of the rectum, have been abandoned by many surgeons because they consider the procedure ineffective and often dangerous resulting in perforation of the bowel. Even when effective, the nuisance and pain involved in dilating the stricture are sufficient to discourage most physicians as well as their patients. Because of obstructive symptoms, as well as inflammatory conditions of the perineum and rectum, many of these patients eventually come to colostomy to divert the fecal stream from the involved area or to relieve obstruction (17). While excision of the strictured bowel is usually reserved for those cases which do not subside after colostomy and the drainage of local abscesses, Turell believes that an abdominoperineal or local bowel excision is usually necessary to arrest the disease. In Woods' series at the Cincinnati General Hospital, there were poor results in 60 per cent of the severe cases of lymphopathia venereum in which colostomy was performed, and only 17.8 per cent of a group of 28 patients with severe disease had what was considered to be a good result.

Many believe that the strictured area is a potentially malignant lesion, as high as 8.6 per cent carcinomatous degeneration of such involved areas of bowel having been reported by Barber and Murphy. Pund and others have thought that lymphogranuloma venereum is a precipitating cause of carcinoma. Pund, in an analysis of 135 cases of carcinoma of the penis, vulva, and anal rectum, found that the incidence of coexistence

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of lymphopathia venereum and carcinoma in these regions was quite high. Rowe believes that the danger of carcinoma developing in the stricture is not significant enough to warrant removal of the diseased area.

Irradiation, according to Woods, has not proved to be of any real benefit. Other methods of treatment that have been recommended are diathermy to the rectum, the use of estrogens, and electrosurgical resection of diaphragmatic types of strictures. With the exception of the latter, applicable only in special cases, we probably cannot expect too much benefit from such procedures. The use of Frei antigen in treating the disease, which was at one time in great favor, has generally been discontinued.

The Lockhart-Mummery combination of colostomy and perineal excision of the rectum has been given ample trial. Edwards and Kendell reported 6 cases treated in this way, with good results in 5 of the patients. Barber and Murphy treated 35 out of 55 patients with relief of symptoms. The difficulty of this procedure, as well as other modifications of the sacral-perineal approach, is that one cannot predict beforehand how high the ulceration and stricture formation may extend and one may run into difficulties in high lesions. Woods and Hanlon and Morris found that abdominoperineal resection of the rectum usually relieved the local and systemic effects of the disease.

With the popularization of the pull-through type of procedure, in which the diseased segment is resected to the mucocutaneous junction and the proximal good bowel is pulled through the anal orifices and sutured in place, as advocated by Swenson in treating Hirschsprung's disease, and by Bacon and Babcock in the treatment of carcinoma of the rectum, it was inevitable that the restoration of anal continence by such a measure after resecting a stricture of the rectum would be advocated. Here, of course, the dangers of recurrence of the lesion by performing a less radical procedure, as pointed out by many in the treatment of carcinoma of the rectum, would not hold.

One of the main objections to the abdominoperineal pull-through procedure has been that even though the anal sphincter is preserved, incontinence will result because of the loss of the rectal anal reflex through resection of the rectum. Gaston has divided fecal continence into colonic and sphincteric types. Colonic continence depends on the adaptation of the colon to the enlarging fecal mass, allowing storage to take place without attempting to force the material along the intestinal tract. This type is present in the colostomized patient as well as in those who have a functioning anal sphincter. In sphincteric continence active contraction of the external anal sphincter resists the propulsion force of colonic peristalsis, the internal sphincter playing no part in sphincteric continence. The external anal sphincter, as with other voluntary striated muscles, tires rapidly and continence is a result of rapid, often subconscious, contractions delicately correlated to colonic activity, rather than a continuous purse-string or pinchcock type of control. The correlation of sphincteric to colonic activity is mediated through a nervous reflex. The afferent fibers of this reflex rise in the wall of the rectum and communicate with efferent fibers at cerebral levels, terminating in the external sphincter. Thus sphincteric continence may be lost by injury to the external sphincter, transection of the spinal cord, injury to the inferior hemorrhoidal nerve supplying the sphincter and removal of the afferent fibers of the rectoanal reflex by resection of all of the rectum. Sphincteric continence is not associated with any dampening effect on colonic peristalsis. The afferent fibers which are not present above the rectum increase in numbers as one approaches the anus. At least 7 centimeters must be present for the reflex to function according to Gaston's (10) work.

From the clinical standpoint we find a great difference of opinion as to the presence of continence if the entire rectum has been removed. Although many, such as Ravitch, believe that control of bowel movements is lost, Bacon and Babcock have been satisfied

with the results in a large series of cases in which this operation was performed chiefly for carcinoma of the rectum. Bacon (4), in 604 pull-through operations for carcinoma of the rectum, had only 3 patients who found a perineal pad necessary when checked 5 to 10 years after operation. This represented 0.7 per cent of cases. Two per cent found it desirable to eliminate fruit juices from the diet. The remainder were on full and regular diets with complete continence. Grinnell and Hiatt have stated that sphincteric control following abdominoperineal pull-through is inferior to that following anterior resection, though the abdominoperineal pull-through has been described as satisfactory. Continence, following the performance of this procedure in cases of Hirschsprung's disease, has generally been described as good.

Hanley has extirpated the stenotic segment of bowel in lymphopathia venereum followed by mobilization of the descending colon and use of a pull-through operation in 8 cases in which the results were considered to be extremely satisfactory. Eiseman in a similar case stated that while the patient's desire to defecate was somewhat different from what had been present previously, she was quite able to feel the presence of a stool in the terminal portion of the bowel and to expel it readily. She was able to hold a stool as long as ½ hour just inside the sphincter.

Breidenbach reported eradication of disease and re-establishment of intestinal continuity with good functional results in 18 cases. He favored perineal resection and anastomoses rather than a pull-through when possible, believing that by preserving the internal rectal sphincter one obtained better continence.

How can one reconcile the conflicting opinions expressed as to continence following resection of the rectum? One must differentiate continence as shown by the perfectly normal individual from that continence demonstrated by the individual who, though not having perfect control, has made a satisfactory adjustment to his situation. For example, some patients with an abdominal colostomy are continent in the sense that they may have 1 or 2 movements a day at no inconvenience to the individual. Also some individuals are seen with imperfect anal control because of old sphincter injuries, yet they are perfectly satisfied with their situation. Often by following the proper diet and the use of an evacuating enema in the morning these individuals are able to get through the day ordinarily without any appreciable difficulty. Bacon (4), although reporting continence in over 99 per cent of cases following pull-through procedures, found that 61 per cent of these patients employed rectal irrigations to initiate defecation or aid in its completion from daily to weekly intervals. On the other hand, some patients after colostomy have a very difficult adjustment, with the result that their physician is so influenced as to feel that colostomy is a procedure incompatible with normal living. In other words, there is a mental as well as physical adjustment to be made. The intelligence, co-operation, and personality of the patient will have a great effect on the results obtained with the pull-through procedure just as in the foregoing situations.

Besides the question of continence, there is a great psychic benefit in having bowel movements through the normal channel and being like other people. This is especially true when the individual must live in close proximity and intimacy with relatives and friends. The wearing of a perineal pad as a safety measure is not unusual in women whose menses make such a situation common, but a pad on the abdomen immediately marks the individual as different.

Breidenbach has advised a preliminary colostomy before attempting to resect the diseased bowel if this has not already been done. If there is difficulty in bringing down the proximal segment of colon to the anus because of the length of the inferior mesenteric, this may be sacrificed and the marginal vessel relied upon to supply blood to the segment from the midcolic vessels. Eiseman reported using a segment of ileum to

bridge between the proximal segment of colon and the anus.

Because of the thickened strictured area, the distal segment of bowel cannot be inverted as in treating Hirschprung's disease but must be resected by incision at the mucocutaneous junction after having been freed from above, usually associated with a posterior sphincterotomy in order to pull the bulky rectum out through the anus. In our cases the strictures were too low to contemplate an anterior resection.

As to whether the pull-through operation should be done as a primary procedure instead of a colostomy is open to question and depends on the amount of reaction and involvement in the diseased area. A preliminary colostomy in severe cases may quiet the process enough so that a more successful definitive procedure could be accomplished at a later time.

While Babcock and Bacon (4) recommend drainage of the presacral space through the abdominal incision, we prefer bringing a drain out through the perineum. The drain can usually be removed before the first bowel movement. Bacon (4), in reviewing the large series of pull-through operations which he has performed for carcinoma of the rectum, has found that in general the complications were of no greater frequency than in the classical abdominoperineal operation. Vesical dysfunction in the form of temporary atonia occurred in 22.6 per cent of cases and infection without retention in 15.6 per cent. None had incontinence. Sexual impotence occurred in 8.3 per cent of cases compared to 95 per cent of cases in which abdominoperineal resection was done. Fortunately, lymphopathia venereum strictures are uncommon in the male in whom the greater number of complications may occur.

During the period from 1945 to 1955 inclusive, at the John Sealy Hospital, we reviewed 46 cases of patients with lymphopathia venereum, 37 of whom had rectal strictures. In the 9 cases in which rectal strictures did not occur, there were 4 colored males. In the stricture group there were 31 colored females, 5 white females, and 1 white male. The ages ranged from 5 to 80 years when these individuals were first seen in our clinic. There was 1 case in the first decade, 1 case in the second decade, 7 in the third, 10 in the fourth, 17 in the fifth, 9 in the sixth, and 1 in the eighth. The duration of the lesion was rather indefinite in most cases, averaging probably from 5 to 10 years. Most of these patients were treated by dilatation, 16 apparently being controlled by dilatations alone. Seventeen came to colostomy because of obstruction, inability to control the inflammatory process, or both. The remainder had no treatment and were lost from follow-up.

Three patients, who had had a previous colostomy, were treated by an abdominoperineal resection of the rectum with a permanent colostomy because of recurrent attacks of inflammation in the perineum and anal region with the constant discharge of purulent material and blood from the rectum. Because of the extent of involvement it was impossible to save the sphincter in 1 of these patients though a pull-through procedure had been planned. An abdominoperineal resection was performed on a fourth patient because carcinomatous changes in the lesion were found by rectal biopsy. Another case of carcinoma in a patient with lymphopathia venereum was treated by colostomy alone as the tumor was considered nonresectable. Abdominoperineal pull-through procedures were attempted in 6 cases. All had had previous colostomies. One patient had such an inflammatory involvement around the anal and perineal region that it was impossible to preserve the sphincter and a permanent colostomy was made on the abdominal wall. This case is included in our group of abdominoperineal resections of the rectum described before. Another patient, when explored from above, was found to have a fecalith the size of an orange impacted in the rectum with a membranous type of stricture distally. With the removal of the fecalith, which had given the impression on rectal examination of a large

area of diseased rectum, it was readily apparent that the strictured area could be controlled locally without a resection of the bowel. This patient had a negative Frei test and probably does not represent a case of true lymphopathia venereum but is mentioned here to demonstrate how one may be misled in such a situation. In the remaining 4 cases in which abdominoperineal pull-through procedures were actually done, all 4 patients had had previous colostomies. The indication for the procedure was to restore the normal bowel continuity as the disease appeared to be arrested. In 1 case in which a transverse colostomy had been performed previously, the pull-through procedure was done, leaving the colostomy to be closed at a later date. Closure was accomplished 6 months later when the patient finally came back for the procedure after much procrastination. She now has 1 bowel movement daily without irrigations and with good control. In 2 of the other 3 cases in which sigmoid colostomies had been previously done, it was impossible to bring the proximal colostomy all the way down without sacrificing the inferior mesentery vessel so the segment of the distal loop of the colostomy above the resected rectum, which appeared to be normal though small from disuse, was anastomosed to the proximal bowel and the distal end anastomosed to the mucocutaneous junction at the anus. The presacral space was drained in only 1 of these cases. A small postrectal abscess developed in 1 of the undrained cases and was incised and drained at the suture line 2 weeks postoperatively. This patient was a 14 year old colored girl who had had a colostomy since she was 5 years of age. She presented a difficult emotional problem. Having never been accustomed to bowel movements in the normal way she made no attempt to go to the bathroom, even after feces had passed out on to the perineum. Her control leaves much to be desired though again, because of a lack of co-operation, it is difficult to tell how much of this lack of control is due to the personality of the individual. On the other hand, the operation has given a new lease on life to another patient who had had a colostomy for 25 years. She and her family are very pleased with the result. She has bowel movements about once every 2 days, occasionally uses enemas, and on rare occasions takes mineral oil for constipation. She is able to recognize when feces have reached the preanal region and is able to control and hold back the movement for as long as an hour until she can reach the proper facility. She no longer wears a perineal pad. She is now able to eat corn and other substances which formerly caused an overactivity of her colostomy. Our last patient is equally pleased following her operation, and we are quite satisfied with the result although only 4 months have elapsed since the procedure was done.

In evaluating continence in our cases of megacolon, in which abdominoperineal pull-through procedures were done, the results have been very satisfactory in the 7 cases in which sufficient time has elapsed to evaluate the procedure.

Though our experience with the abdominoperineal pull-through procedures has been limited in the treatment of lymphopathia venereum, we believe that this procedure should be recommended to patients who are not satisfied with a permanent colostomy or who are having further difficulty following the colostomy and removal of the rectum is considered necessary. While probably not giving completely normal continence, we believe the procedure is superior, from both the functional and the psychic standpoints, as compared with an abdominal colostomy.

SUMMARY

The application of the abdominoperineal pull-through operation to cases of rectal stricture resulting from lymphopathia venereum is discussed both from the theoretic and from the clinical standpoints. Our experience in the surgical treatment of strictures of this type at the John Sealy Hospital is reported.

REFERENCES

1. Anderson, O. L., and Harmos, O. Lymphopathia venereum. Surgery, 1938, 3: 41.
2. Babcock, W. W. Radical single stage extirpation for cancer of large bowel with retained functioning anus. Surg. Gyn. Obst., 1949, 85: 1.
3. Bacon, H. E. Cancer of the rectum. Surgery, 1949, 26: 584.
4. Idem. Abdominoperineal proctosigmoidectomy with sphincter presentation. J. Am. M. Ass., 1956, 160: 269.
5. Barber, W. H., and Murphy, W. B. Lymphogranuloma venereum. Ann. Surg., 1941, 113: 30.
6. Breidenbach, L., and Slattery, L. R. The selection of an operative procedure for patients with lymphogranuloma venereum of the rectum. Surg. Clin. N. America, 1949, 35: 399.
7. Edwards, M., and Kendell, F. B. The treatment of rectal lymphogranuloma by excision. Surgery, 1938, 4: 809.
8. Eiseman, B., and Mueller, C. B. A new operative approach to inflammatory strictures of the rectum and recto-sigmoid. Surgery, 1951, 30: 448.
9. Gaston, E. A. The physiology of fecal continence. Surg. Gyn. Obst., 1948, 87: 280.
10. Idem. Fecal continence following resections of various portions of the rectum with preservation of the anal sphincters. Surg. Gyn. Obst., 1948, 87: 669.
11. Grinnell, R. S., and Hiatt, R. B. Ligation of the inferior mesenteric artery at the aorta in resections for carcinoma of the sigmoid and rectum. Surg. Gyn. Obst., 1952, 94: 526.
12. Hanley, P. H. Personal communication.
13. Morris, J. H. Abdomino-perineal resection of the rectum for lymphogranuloma. Ann. Surg., 1940, 111: 152.
14. Pund, E. R., and Lacy, G. R., Jr. Lymphogranuloma venereum (inguinale). A precipitating cause of carcinoma. Am. Surgeon, 1951, 17: 711.
15. Ravitch, M. M. Diagnosis and treatment of carcinoma of recto-sigmoid and anorectal areas. Am. Surgeon, 1951, 17: 819.
16. Rowe, R. J. Granulomatous lesions of the anorectal region. South. M. J., 1952, 45: 91.
17. Singleton, A. O., Jr. Diseases of the Lymphatics, Cyclopedia of Medicine, Surgery and Specialties. Philadelphia: F. A. Davis Co., to be published.
18. Swenson, O., and Fisher, J. H. Treatment of Hirschsprung's disease with entire colon involved in aganglionic defect. Arch. Surg., 1955, 70: 535.
19. Turell, R., Krabauer, J. S., and del Maynard, A. R. Colonic and anorectal function and disease. Surg. Gyn. Obst., Internat. Abst. Surg., 1953, 96: 434.
20. Woods, F. M., and Hanlon, C. R. Inflammatory strictures of the rectum. Tr. Am. Surg. Ass., 1944, 62: 598.

EDITORIALS

CHEMOTHERAPY AND THE SURGEON

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THE THESIS of "selective toxicity" has guided research in many fields and resulted in incalculable benefits to mankind. One has only to review the development of compounds to control noxious plants, insects, parasites, and bacterial infections in animals and man.

It is interesting and of importance to note that in many of the most successful applications of this principle, the development of effective compounds did not await complete knowledge of the underlying mechanism of their action. Indeed, the exact method of antagonism is often unknown in most instances. Further, successful applications have resulted from taking advantage of quantitative differences between the desirable and undesirable agents. An example is the effective use of certain weed-killers as a result of the differential absorption by broad leaves rather than the narrow ones of the fine grasses—the inherent susceptibility of both groups to the poison is apparently the same.

In recent years, there has been an ever increasing interest in the investigation of compounds with possible "selective toxicity" for malignant tissue. The success of temporary hormonal control of some carcinomas of the prostate and breast resulted in heightened activity in the search for additional compounds with antitumor activity. The majority of clinical studies have been carried on in patients with leukemia and malignant lymphomas, as a result of the early observations of clinical benefit and the relative ease in evaluating physiologic effectiveness. Yet, it must be remembered that these malignancies constitute only a small fraction of the total problem and there may be important metabolic differences between them and the "solid" tumors which might not select agents with activity in the latter group.

The systematic investigation of the effects of possible cancer chemotherapeutic agents against the solid tumors, which make up the greatest portion of malignant tumors has been somewhat neglected. Although, the clinical effectiveness of presently available chemotherapeutic compounds upon solid tumors has been disappointing, the sporadic attainment of dramatic regressions or suppression of tumor growth following the administration of such drugs would indicate that future success may be accomplished.

In recognition of the progress to date and the magnitude of the problem remaining, the Cancer Chemotherapy National Committee was created to develop general policies, assist in obtaining financial support of research, co-ordinate the activities of interested scientists and clinicians, and promote the exchange of pertinent information. A Cancer Chemotherapy National Center was established with five technical advisory panels: (1) chemistry, (2) pharmacology and biochemistry, (3) tumor screening, and (4) clinical, to aid in making a concerted, rational attempt to facilitate these policies.

Briefly, a large number of natural products and synthesized compounds have al-

ready been tested by microbiologic techniques and against transplanted tumors in mice. Paralleling these studies are the efforts of the Pharmacology Panel to increase the information available on the mechanisms of action of compounds already proved to have anticancer activity.

The Clinical Panel has been given the responsibility of stimulating the interest of clinical groups in the systematic evaluation of compounds now available for clinical trial. In addition, co-operative studies involving groups of clinicians in several institutions using a common protocol have been encouraged to re-evaluate some of the agents already in use. By such techniques, a sufficient number of patients treated by alternate methods according to a single protocol can be evaluated in a statistically valid manner. There is a great necessity for setting up additional groups to study the clinical effects of compounds which should be available in the near future.

Surgeons by nature and training are well qualified to take part in such studies. The care of patients with such lesions has always been predominantly the responsibility of surgeons, yet even with the best surgical techniques available, not more than 30 per cent of the major types of malignancy are curable.

The importance of the addition of new therapeutic techniques to the surgical armamentarium should be obvious. The need for surgeons to undertake the study of the physiologic principles of cancer chemotherapy is quite comparable to the participation of surgeons in studies of cardiovascular physiology in order to increase the scope of their therapeutic effectiveness in that field. Further, surgeons have the best opportunity of observing patients in all stages of their disease, and thus, should be better able to evaluate significant changes which may be of importance in indicating some, as yet, unnoted aspect of therapeutic effectiveness.

RUPTURED ABDOMINAL ANEURYSM—TRANSTHORACIC CONTROL

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ALL AGREE that ruptured abdominal aneurysm is a surgical emergency which can be treated by graft replacement. We, as well as others, have stressed the importance of pain in an aneurysm as indicative of either actual or impending rupture. In addition, such pain may be present from hours to weeks before clinical rupture takes place; even in the latter circumstance death seldom occurs immediately. Usually, a grace period of a few to several hours is available to insure an attempt at surgical correction. While almost all who have faced this catastrophe have survivors to attest to the validity of the surgical approach to this otherwise hopeless situation, most are not sufficiently proud of their results to quote statistics.

Many factors undoubtedly contribute to the presently high mortality rate. There is little to be gained here in extolling the virtues of elective surgery, the endowments of youth, a normal cardiovascular system, and a normal blood volume in a nonstressful setting. The direct antithesis of the ideal surgical candidate is indeed the patient with ruptured abdominal aneurysm.

Experience has indicated a maneuver which has proved valuable in reducing the mortality: viz., transthoracic aortic control. Some time ago, faced with an elderly patient with ruptured abdominal aneurysm, my operative assistant and associate, Lester R. Sauvage, raised the question of a thoracotomy to control the aorta; at this point during induction, the anesthesiologist was unable to obtain a pulse; consequently a thoracotomy became a necessity for cardiac arrest and aortic control. The thoracotomy was quickly accomplished; however, operations which begin with cardiac arrest seldom turn out well. This case was no exception. Nonetheless, transthoracic aortic control has become a standard procedure on my service.

The dictum of the vascular surgeon has always been to control all potential areas of possible blood loss prior to definitive therapy. Aside from this important concept in the treatment of large vessels, transthoracic aortic control is a logical maneuver and specifically in this situation has virtues other than the control of a sudden large blood loss. Actually, there are 3 main danger points in the management of the patient in the operating room. The first occurs with induction of anesthesia, the second at the time of abdominal laparotomy, and the third when inadvertent entrance is made into a retroperitoneal hematoma in continuity with the site of aortic tear. When the latter is anterior, it may create no serious problem; however, if lateral or posterior high in the subrenal aorta, it may be extremely difficult to control. The latter danger needs no further elaboration. The first 2 danger points of the operation lend themselves to ready explanations which appear valid.

The patient with ruptured aneurysm has a low blood volume because of blood loss. As in the patient with hemorrhagic shock, protective adjustments, particularly by vasoconstriction, occur; this, in effect, husbands the available volume into a central circulating blood mass. With the induction of anesthesia, the protective mechanisms are ablated, and vasodilatation occurs. Simultaneously, the blood pressure falls at times to unmeasurable levels, and the stage may be set for a cardiac arrest or a myocardial infarction. Obviously, whether or not this circumstance occurs is dependent upon many factors inherent in the patient and his condition. If it occurs, the danger will be po-

tentiated by the laparotomy incision, or the latter may initiate serious hypotension of itself. Ordinarily, the intra-abdominal pressure is slightly negative. Is it not logical to assume that the abdominal pressure becomes more positive with a large retroperitoneal hematoma and edema? Dependent upon the degree of abdominal muscular tone, pain, and spasm, positive pressure acts as a tamponade to continued blood loss via the aortic tear. By laparotomy incision the abdominal pressure is immediately reduced to atmospheric; thus, all support of the tamponade effect is lost. It is conceivable that additional bleeding may occur retroperitoneally or the abdominal vascular bed may become more capacious. These features are abetted, of course, by anesthesia. These factors have not been documented scientifically, and it is hoped to study them further; however, these danger points are real, for they have been observed by the editorialist. The explanations proffered for these occurrences are rationalizations based upon known facts; they do not, however, appear to be unreasonable assumptions.

Because of past experience, the following routines have been practiced in the management of the patient with ruptured abdominal aneurysm:

1. The abdomen and left thoracic area are shaved in the ward.

2. With the awake patient supine on the operating table, the abdomen and left thorax are prepared and draped.

3. Immediately before the anesthesiologist is ready to induce the patient, 1 or 2 units of blood are rapidly transfused.

4. Rapid induction is performed with cyclopropane, and intubation assisted by succinyl choline. If expertly done, the patient is ready for incision within 1 minute.

5. As soon as the surgeon is informed that the patient is asleep, an anterior left thoracotomy incision is made in the ninth intercostal space, the ninth rib is sectioned anteriorly and posteriorly, and if inadequate, the eighth rib is also sectioned. A rib spreader is inserted and the aorta is located. If a significant pressure drop has occurred, the *lowermost* aorta is compressed against the vertebral column. Periodically partial release is carried out until the pressure has stabilized. An assistant is assigned to aortic compression dependent upon the pressure changes.

6. The laparotomy incision is made. In the event of a pressure drop, aortic compression is utilized as needed. The operation now may proceed more leisurely with the assurance that the situation is controllable. If an accidental entry is made into the hematoma contiguous with the aortic tear, the immediate danger to survival is averted by transthoracic aortic control. Back bleeding is seldom a serious problem. The iliacs are easily occluded if necessary and bleeding via the lumbar arteries usually is not great. Thus, the important proximal dissection may be unhurried and carried out with care to prevent injury to the third portion of the duodenum, the inferior vena cava, and renal arteries. As soon as the subrenal aorta is clamped, the need for thoracic aortic control is obviated; the operation then becomes routine.

As in many procedures which allow a surgical advantage, possible disadvantages must be carefully weighed. Two questions pertinent to normal thermic conditions quickly arise. How long can one safely occlude the aorta at this level without fear of permanent ischemic damage to the cord or cauda equina? And what about the kidneys? Actually, very little definite information is available concerning the dangers of occlusion at the tenth dorsal level and with a normal temperature. Embryologically, the blood supply to the cord is segmental. These vessels anastomose with each other on the cord. As development progresses by attrition, the segmental branches, particularly in the thoracic cord, become less important and the predominant supply to the human cord is mainly via 6 to 8 large anterior radicular arteries, and it is on these that the spinal cord depends largely for its blood supply. Their distribution is not symmetrical. There are usually 1 or 2

in the lumbar region, which are the largest, and 1 or 2 in the cervical region, which are the next largest. One to 2 additional smaller branches occur in the upper thoracic, and 0 to 1 in the lower thoracic region. The major vessel to the cord is the anterior spinal artery. This vessel receives its major supply from the radicular arteries above and borrows the channels of the original segmental arteries; consequently, it maintains its contiguity the length of the cord. The largest tributary is usually the one in the lumbar and lower thoracic region, namely, the arteria radicularis magna. This artery measures 872 microns in the adult. It is single and occurs usually on the left side. Its most frequent site is at level of the second lumbar, but it may be observed at any segment between the eighth dorsal and fourth lumbar levels. In the middle thoracic region large segmental arteries are absent in many cases. The anterior spinal artery is largest in the lumbar area, next in the lower thoracic, upper cervical, lower cervical, upper thoracic and middle thoracic regions. The narrowest portion of the anterior spinal artery is halfway between adjoining significant radicular arteries. This fact has suggested that the flow of blood in the anterior spinal artery from 2 major radicular arteries may be in opposing (converging) directions.

The posterior radicular arteries are similar in distribution. The arteries and their anastomoses are smaller than those of the anterior radicular arteries. There is no continuous posterior spinal artery. The anterior radicular veins resemble in number and distribution the anterior radicular arteries. There is a nonsymmetric pattern and usually they do not reach the spinal cord by the same roots as the significant radicular arteries.

Experimental injections into the vessels of the human cord have produced inconsistent findings. Tanon (1908) found that whereas he could fill the vascular system of the entire cord from injections made into the lumbar vessels, injections into the thoracic portion above the ninth segment filled only small stretches, and in the cervical region the territory was only slightly larger. (Suh and Alexander found that injections from above could only be made into the cervical region and from below only into the lumbar and thoracic regions.) Apart from possible criticisms of the technique and injection media employed, the discrepancies may be explained by the effects of postmortem clotting in the vessels and the trauma associated with removal of the spinal cord from the cadaver. It is undesirable to draw inferences as to the normal direction of blood flow in the midline anastomotic chain from the behavior of injection media introduced after death at a single point into the vascular system of the isolated human spinal cord.

The pattern of changes in the potential complex of the spinal cord that takes place during anoxia is remarkably specific and consistent. This change sequence clearly helps establish the differential vulnerability of a number of cord structures to lack of oxygen. Thus, quantitation of differential vulnerability is possible. For peripheral nerves (frog) at room temperatures anoxic block of the excitation mechanism begins after 80 to 90 minutes and is complete after more than 2 hours of total anoxia. The shorter survival time of cord structures, particularly of secondary neurons, must be related to the higher oxygen consumption, a smaller oxidized reserve, or both. The maximum duration of spinal cord ischemia compatible with complete physiologic recovery of function and complete absence of cellular destruction is about 15 minutes. Irreversible damage occurs after longer periods of ischemia, and about 1 hour of complete ischemia kills all cells.

My neurologist colleague, Fred Plum, informs me that intermittent compression up to 15 minutes with release for a minute or two, should avoid cord damage. It should be emphasized that duration of compression should be by the clock. The kidneys are being less sensitive than the spinal cord to anoxia and should be unaffected if this procedure is observed; and, of course, would tolerate longer periods without ill effects.

There are those who believe that abdominal compression immediately following laparotomy is adequate. This has been difficult to effect and relatively unsatisfactory in our hands as well as traumatic to upper abdominal viscera, particularly the pancreas. It is apparent that the danger points previously alluded to would not be avoided. Transthoracic aortic control is merely one method of effecting control of the total situation. In our experience it has saved lives and improved our results with ruptured abdominal aneurysm. Except for unusual circumstances, if the time limitations of compression are adhered to, minimal or no adverse effects should result. It is a calculated risk; this is not a new experience, for the surgeon daily weighs the risk versus advantage.

THE SURGEON AT WORK

AIDS IN PROCTOLOGIC SURGERY

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THIS ARTICLE deals with the successful employment of scientific gadgetry in the performance of the last 250 consecutive anorectal surgical procedures. These instruments particularly facilitate the performance of hemorrhoidectomy and excision of chronic anal fissure (ulcer). The former operation has been utilized in over 1,000 and the second technique in over 500 personal cases that have been followed for at least 30 months. In my experience, the incidence of complications, such as those reported by Anderson and associates which are said to be physically disabling and psychologically disturbing, has been extremely low or inconsequential following the proper execution of the foregoing surgical procedures even when performed by assistant residents in training. Postoperative stenosis has not been observed to date.

Ring retractor (Fig. 1). Following a clinical trial with a ring retractor which was first suggested by Marshall, I have adopted its use because it affords wide exposure of the field of operation with ease in most, though not in all, cases. A flat metal ring was constructed that has an inside diameter of about 15 centimeters (6 inches) and 5 slits with a traveling range of over 8 centimeters (3 inches) which accommodate movable holders with screw-on mechanisms. Each holder is fitted with a flat blade that in turn has a longitudinal slit of over 8 centimeters (3 inches) long and 2 sharp, moderately bent hooks at the end that fasten to the perianal skin and hold the ring in place without assistance. When the hooks of 4 of the 5 blades are attached to the perianal skin and retracted for the proper distance (this varies with each patient), the anal orifice is pulled wide open and remains exposed for the duration of the application of the ring (Fig. 2). At the conclusion of the operation the blades are released and the ring comes off easily. To date the skin where the hooked ends of the blades were held has healed promptly and uneventfully. By employing this ring properly a hemorrhoidectomy may be performed easily with the aid of 1 assistant—an intern or nurse.

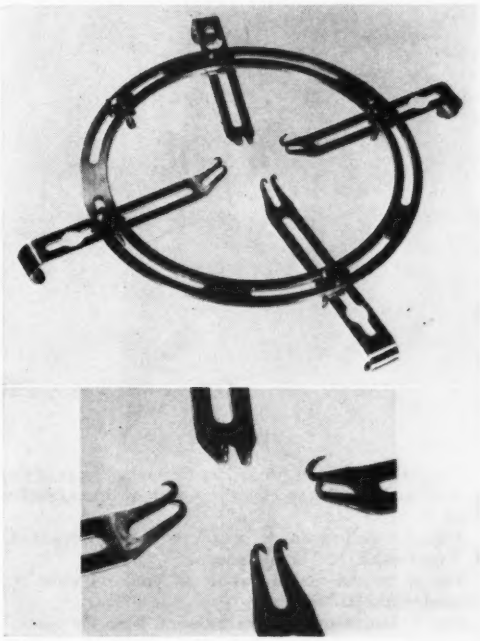
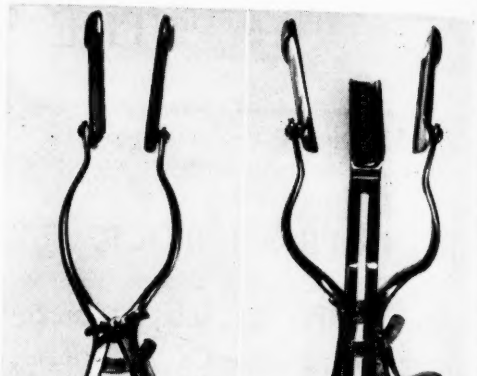


FIG. 1. Ring retractor: above, assembled; below, magnification of hooked end of the retracting blades.

FIG. 2.



a b

FIG. 3.

a b

FIG. 4.

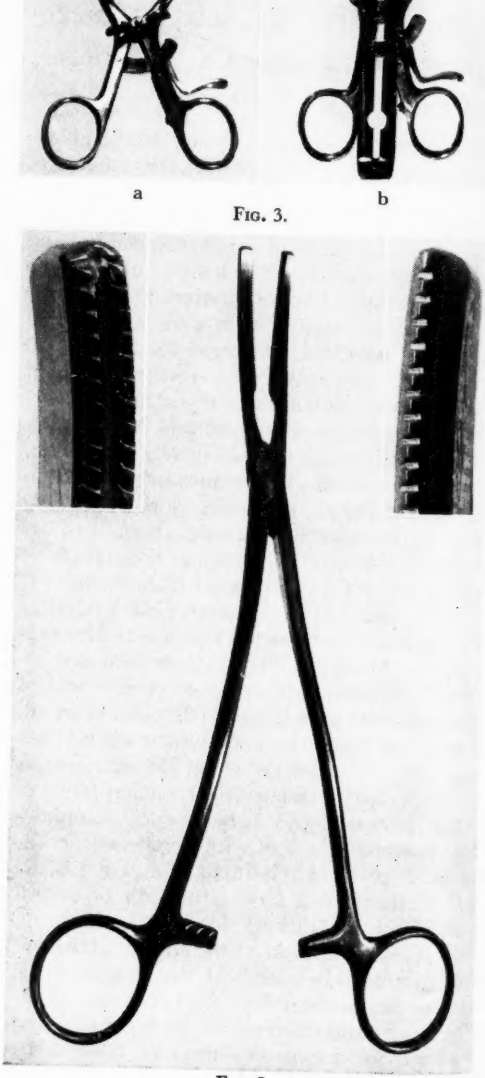


FIG. 5.

FIG. 2. Retractor in situ before commencement of the operation. Note the excellent exposure of the operative field.

FIG. 3. Self-retaining anal retractor assembled. a, Two bladed. b, Three bladed.

FIG. 4. a, Angulated handle of anal retractor. b, Conventional Hill-Ferguson type.

FIG. 5. Multitoothed pedicle clamp. Note the magnified lateral view of the single row of teeth in one jaw (right), and of the double row of teeth and the central groove in the second jaw (left).

A self-retaining anal retractor (Fig. 3). This is a modification of the Barr retractor to which have been added the Smith type self-retaining swivel side blades which are attached to the distal end of the arms. These are controlled by a locking mechanism located at the proximal end of the arms. A third, or center blade, the distal end of which is concaved and rounded, has been added and fastened by a setscrew in the center of the instrument. This 3 bladed anal retractor affords excellent exposure of the anal canal and is most useful in operations for excision of anal ulcers or fistulas which are complicated by a ring of large mixed hemorrhoids or redundant mucosa or skin; in some of these instances this retractor is almost indispensable.

Blade-like anal retractor (Fig. 4). The Hill-Ferguson type retractor is made with various sized blades and with angular shafts that are fitted with light hollow handles. The angularity of the shaft makes for easier holding of the handle and it is out of the operative site along with the assistant's hand thus effecting better exposure and visualization of the field of operation.

Multitoothed pedicle clamp (Fig. 5). The inner surfaces of the specially curved jaws of this clamp are provided with many fine relatively sharp but short teeth. One jaw contains a single row of teeth while the other has 2 rows; the single one fits into a central groove of the jaw with the 2 rows of teeth thus holding the clamped tissue firmly upon closing of the jaws with minimal crushing or injury to the grasped tissues. This instrument is ideal for clamping of the mucosal pedicle in hemorrhoidectomy or in the excision of anal ulcers or anal fistulas.

SUMMARY

Personal experience with 2 new and 2 modified instruments as used in 250 consecutive proctologic operations is reported. This scientific gadgetry provides excellent exposure of the operative field, facilitates the performance of anorectal operations, and makes possible the execution of these operations with the aid of only 1 assistant—an intern or nurse. These instruments are also favored by many members of the house staff who are in training in general surgery. These instruments are intended to complement the sound surgical refinements of the basic surgical concepts and principles.

REFERENCES

1. ANDERSON, R. E., PONTIUS, G. V., and WITKOWSKI, L. J. Complications following surgery for benign anorectal lesions. J. Am. M. Ass., 1955, 159: 9.
2. MARSHALL, G. R. New anal retractor. Northwest M., 1934, 33: 284.

TECHNIQUE FOR REPAIR OF ATRIAL SEPTAL DEFECT USING THE ATRIAL WELL

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TECHNIQUES FOR REPAIR of atrial septal defects must entail a low operative mortality, and must allow opportunity for complete and permanent repair of the type of defect encountered. The atrial well technique of Gross has met these criteria in our experience. Seventy-one patients with atrial septal defect and left-to-right shunts have been operated upon at the Mayo Clinic by this method, with 3 deaths, giving a mortality rate of 4 per cent. Complete closure has been obtained in all except a few early cases, as documented by physiologic studies in the first 33 patients (2).

Although apparently complex and difficult of execution, the technique can be made easily reproducible by attention to detail. The following description applies to repair of a large atrial septal defect, with a rim of septal remnant all around the aperture. With minor modifications the method is easily employed for defects without septal remnants in various areas. Its applicability has been described by our group in cases of atrial septal defect with anomalous pulmonary venous connection (3) and in cases of common atrioventricular canal (4). Anesthesia and supportive care during these operations are described by Patrick and Theye.

POSITION OF PATIENT AND EXPOSURE

The patient lies semisupine with the right side of the thorax elevated at an angle of approximately 30 degrees from the horizontal. This position is maintained by the use of bolsters held against both sides of the thorax and by fixation of the extended right arm in a splint attached to a suitable cross bar at the head of the table. Slight traction is applied to the right arm to pull the scapula forward. The hips are immobilized with a wide canvas sling.

A right anterolateral incision is made over the fifth intercostal space and carried anteriorly beneath the breast. Posteriorly, the incision curves below the angle of the scapula to follow the line of the vertebral border of the scapula for a short distance. After division of the muscle layers, the thorax is entered through the fifth interspace. The incision in the interspace is extended anteriorly, after ligation of the internal mammary vessels, by detaching the costal cartilage of the fifth rib from the sternal edge. It may be necessary, on occasion, to sever the fourth costal cartilage similarly. Wide exposure is obtained by the insertion of a self-retaining retractor.

After retracting the lung posteriorly with a moist pack, the pericardium is incised vertically, parallel and anterior to the phrenic nerve. Superiorly the pericardial incision curves slightly forward to extend just beyond the tip of the atrial appendage, and inferiorly it reaches to the diaphragm. Interrupted silk retraction sutures are inserted in both pericardial lips.

ATTACHMENT OF ATRIAL WELL

Four interrupted sutures of No. 000 silk are inserted into the presenting anterolateral wall of the right atrium, along a line from the base of the atrial appendage toward the point of entrance of the inferior vena cava. As these are held upward by an assistant, a suitable clamp is placed beneath them, excluding a portion of the atrial wall (Fig. 1). The heel and handle of the clamp lie inferiorly. The blades of the clamp are of such a length (9 cm.) that the excluded portion of atrial wall will, when opened, accurately fit the diameter of the base of the rubber well (7 cm.). The excluded portion of atrial wall is opened longitudinally, leaving sufficient intact wall at each end of the clamp to allow accurate attachment of the well at these points.

The base of the rubber well is now sewn to the outside of the lips of the atrial incision (Fig. 2). A mattress suture of No. 000 silk is first inserted at each end of the atrial incision and at appropriate positions at the base of the well, the well then

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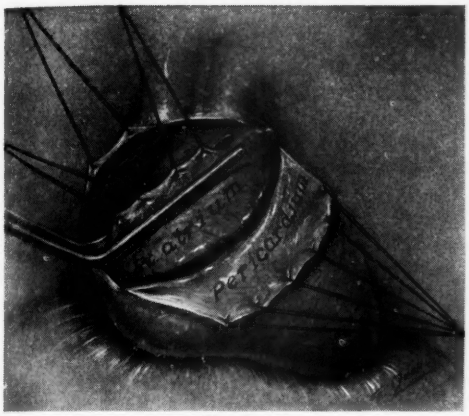


FIG. 1.

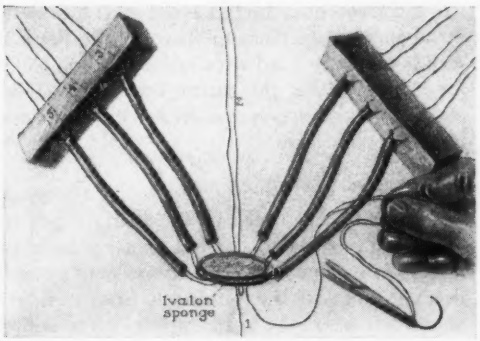


FIG. 3.

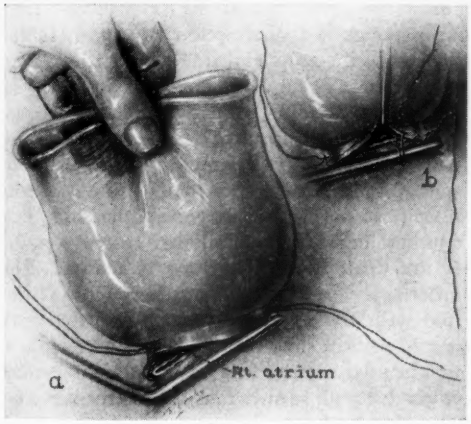


FIG. 2.

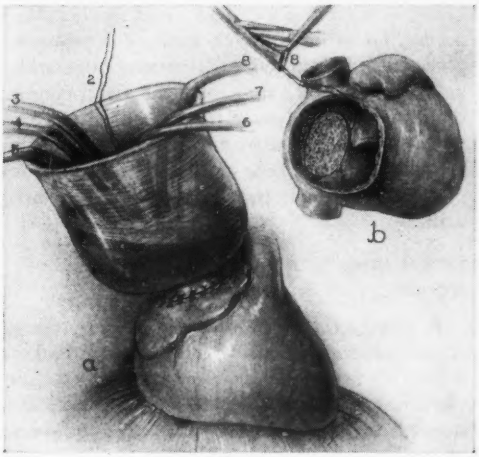


FIG. 4.

FIG. 1. Exclusion of a portion of the wall of the right atrium. A long incision is to be made in this, or entrance into the right atrium after attachment of the well.

FIG. 2. The atrial well is being attached to the outside of the lips of the atrial incision. a, Note placement of the mattress sutures. b, A continuous suture is employed between the interrupted mattress sutures at each end.

FIG. 3. Mattress sutures have been placed through the polyvinyl-formal (ivalon) sponge. They are segregated and identified by being passed through lengths of Penrose drains and long blocks of sponge. Since the sutures at either end are placed in the septal remnant before the bevelled sponge is lowered into the heart, they need not be so treated. Note the method of holding the free end of the suture so that the needle cannot be lost.

FIG. 4. a, Suture *1* has been placed, tied, and cut. Suture *2* has been placed and is ready to be tied. b, All sutures except No. *8* have been placed, tied, and cut. The Penrose drain is being removed from this last suture, preparatory to its placement through the appropriate location in the septal remnant, after which it will be tied down.

being lowered into position by the assistant while these are tied. A continuous suture is now inserted anteriorly and posteriorly to attach the base of the well to the atrium, picking up the atrial wall as a Lembert type of stitch to add strength to the suture line. By placing these stitches close to the edge of the atrial incision leakage from stitch holes which pierce the endocardium will be avoided when the atrial incision is later closed.

The junction between the base of the well and the atrial wall is examined from within the well

to be certain no sutures have passed across the atrial incision to pick up the opposite lip. The well is partially filled with saline solution to test for leakage along the suture line which, when leakage is present, is repaired with additional interrupted sutures.

INITIAL EXPLORATION OF ATRIUM

The well is held open by the assistant and the atrial clamp released. Digital exploration of the atrium is carried out, once the patient's condition permits, with the thumb and first two fingers of the left hand. The size of the defect and its position, together with those of related structures, are readily estimated in this fashion, the method being superior to the use of the index finger alone. A sketch of the defect and its relations is made. An arbitrary time limit of 3 minutes is placed on this initial exploration, heparin not being given at this time, and the atrial clamp is then reapplied. Most of the blood remaining in the well is removed by suction, sufficient being left, however, to allow clotting in the interstices of the suture line between the well and the atrial wall.

PREPARATION OF POLYVINYL-FORMAL (IVALON) SPONGE

A piece of noncompressed polyvinyl-formal (ivalon) sponge about 4 millimeters in thickness is suitably fashioned and its edge bevelled. Long (36 inch) mattress sutures of No. 00 silk are now inserted through the bevelled edge of the sponge in such a manner that when the sponge is later positioned in the defect, the ledge of the sponge will lie on the left atrial side of the septum and the sutures can be tied on the right of the septum. By bevelling the edge of the sponge and suturing the ledge so created to the left side of the rim of septal tissue surrounding the defect, the sponge will be abutted against edges of the defect by the higher left atrial pressure. To avoid crossing of the threads the two ends of each mattress suture are threaded in turn through a length of Penrose tubing and again through a block of polyvinyl-formal sponge, the Rumel tourniquet needle being used for this purpose (Fig. 3). Three or 4 sutures are placed in the sponge anteriorly and posteriorly, each group being attached to a block of sponge as described. The superior and inferior sutures (Nos. *1* and *2*) are, however, held in separate clamps, for they are to be inserted first, before the sponge is lowered into position.

SUTURE OF SPONGE INTO DEFECT

Two to 3 minutes prior to reopening the atrial clamp, heparin is given intravenously in a dose of 1.5 milligrams per kilogram of body weight. An additional dose of 0.75 milligram per kilogram of body weight is necessary if the well remains open longer than 20 to 30 minutes or if clotting occurs within the well prior to this time.

The bevelled polyvinyl-formal sponge with the attached sutures is now moved to a convenient position adjacent to the mouth of the well, taking care that the sponge does not become twisted on itself. The well is held open by the assistant and the atrial clamp released. With the sponge lying outside the well the first stitch (No. *1*) is inserted into the rim of the atrial defect adjacent to the inferior vena cava. This is followed by a similar stitch (No. *2*) adjacent to the superior vena cava. The sponge is then lowered into position and pushed to the left atrial side of the defect. Mattress sutures *1* and *2* are now tied and cut (Fig. 4). Each remaining suture, after being released in turn from its protective sheath of Penrose tubing and from its identifying position in the sponge block, is inserted, tied, and cut. Beginning posteriorly and above, and working in a counterclockwise direction, the sutures (Nos. *3* to *8*) are dealt with in an orderly manner. This order is preferred, for the sutures tend to be carried with the stream of blood toward the tricuspid orifice; should the reverse order of insertion be used, sutures *3* to *5* would tend to become entangled with sutures *6* to *8* while the latter are being inserted.

A Mayo No. 6 taper-pointed half-circle needle, held in fishhook fashion by a 10 inch needle holder, is used to insert the mattress sutures. The needle holder is manipulated with the right hand, the needle point being guided from left to right through the septal rim of the defect, and pulled through, with the thumb and index finger of the left hand. During insertion, the free end of each suture is held as a loop by the assistant to prevent accidental loss of the needle within the heart. To assist in the accurate placement of the second end of each mattress, the assistant tugs gently on the already inserted end, thus guiding the surgeon's finger into the correct position.

Following insertion of all the mattress sutures, the junction between the sponge and the rim of the defect is carefully palpated and any remaining gaps are closed by the insertion of simple through-and-through sutures, with the needle held by the needle holder in regular fashion.

CLOSURE

The atrial clamp is reapplied and the well disconnected from the atrium. Protamine sulfate, equivalent to the amount of heparin previously administered, is now slowly given intravenously. Clotting time is determined 5 to 10 minutes later. In no case has further use of protamine sulfate been indicated.

The incision in the atrial wall is closed with 2 rows of continuous No. 000 silk stutures. The pericardial edges are approximated, leaving a defect at each end. Adequate drainage is insured by inserting a No. 14 French whistle-tip catheter in the dependent portion of the pericardial sac and connecting it to a source of continuous negative pressure of 15 millimeters of mercury. This catheter is removed in 24 hours.

Two catheters for temporary closed intercostal drainage are inserted through stab wounds into the right pleural space. The thoracic wall is closed in layers in the usual fashion.

REFERENCES

1. GROSS, R. E., WATKINS, ELTON, JR., POMERANZ, A. A., and GOLDSMITH, E. I. A method for surgical closure of interauricular septal defects. Surg. Gyn. Obst., 1953, 96: 1–23.
2. KIRKLIN, J. W., DAUGHERTY, G. W., BURCHELL, H. B., and WOOD, E. H. Repair of the partial form of persistent common atrioventricular canal; so-called ostium primum type of atrial septal defect with interventricular communication. Ann. Surg., 1955, 142: 858–862.
3. KIRKLIN, J. W., ELLIS, F. H., JR., and WOOD, E. H. Treatment of anomalous pulmonary venous connections in association with interatrial communications. Surgery, 1956, 39: 389–398.
4. KIRKLIN, J. W., WEIDMAN, W. H., BURROUGHS, J. T., BURCHELL, H. B., and WOOD, E. H. The hemodynamic results of surgical correction of atrial septal defects: a report of thirty-three cases. Circulation, 1956, 13: 825–833.
5. PATRICK, R. T., and THEYE, R. A. Unpublished data.

THE SURGEON'S LIBRARY

Reviews of New Books

IT HAS LONG BEEN RECOGNIZED that *Christopher's Textbook of Surgery*[1] is an authoritative reference in the field of surgery. The changes in the new sixth edition reflect the effective editorial skill of Loyal Davis, as well as the enormous strides that have been made in the various fields of surgery since the preceding edition. Dr. Davis has brought to this text the wealth of his experience. This is reflected in various improvements in this new edition.

The addition of certain new chapters has long been needed in a surgical text. The addition of the chapter on "History of Surgery" by Allen Whipple recognizes the contributions and influence of surgeons of the past upon our present day thinking. This chapter, interestingly written by Dr. Whipple, fills a previously neglected gap. The concluding chapter on the "Qualifications of a Surgeon" by Dr. Hawley has also been previously neglected by textbooks in this field. Dr. Hawley, long recognized as a champion of high standards in surgery, has presented in a straightforward manner his views on the ethics and morals of the practice of surgery. Another attractive addition which has enhanced the volume is the short biographic sketch of the contributor which precedes each chapter.

In general, each chapter of the new edition is written by an authority in his field and, as outlined in the preface, the chapters are not intended to be encyclopedic in scope; but rather an interestingly told story which will cover the subject in general and stimulate the student to inquire further into the subject covered. This has made the new text more readable than the preceding edition. At the end of most of the chapters there is an excellent list of references which will aid in further investigation into each subject.

Newly added is the chapter on "Endocrinology and Metabolism in Surgical Care." This section, by Francis Moore and Richard W. Steenberg, summarizes the new knowledge which has resulted from laboratory investigations into the relationship of endocrinology to surgery as brought to light during the last 10 years. This and Bernard Zimmerman's chapter on "Fluid and Electrolyte Balance" are useful guides to older surgeons whose formal training antedates so much of this rapidly unfolding picture.

All of the chapters have been arranged and emphasis has been transferred to the segments of surgery in which the greatest advances have been made in the past decade. The sections on the "Heart and Pericardium" and the "Vascular System" are among the more striking chapters in that they reflect many new surgical procedures which were unheard of at the time of the publication of the previous text. Practically all of the chapters have been made more interesting in that they present each authority's own views concerning the subject allotted to him. Some chapters in doing this, however, are not as inclusive as one expects in a textbook—and could be of disservice to the inexperienced. For example, in the section on "Thyroid and Parathyroid," the authors cover the controversial subject of thyroid cancer rather superficially, and almost with a dogma that may be objectionable to some readers. Dr. Crile's challenging views on this subject have proved a worthwhile stimulus to the profession, but in a textbook they might serve a still more useful purpose if balanced with the documented views and experience of others. Ian MacDonald, in his chapter on "Breast," handles a controversial subject in sufficiently provocative detail that the reader is made aware, not alone of Dr. MacDonald's editorial viewpoint, but equally of the viewpoints of the various authorities who have written on the subject of breast cancer. And even here, the bibliography neglects direct reference to important contributors in the phase of hormonal control of recurrent cancer, although this facet of the subject is well summarized. Obviously this simply serves to demonstrate the increasingly impossible task of covering in an exhaustive fashion the uncrystallized aspects of a number of subjects, and as Dr. Davis states in the preface, this was not the goal of this edition.

The chapter on the "Female Reproductive System," written by Drs. Burch, Lavely, and Chalfant is interesting in the light of Dr. Burch's extensive experience in general surgery as well as gynecology. It reflects a rich clinical experience and points up indirectly the recognition of the need on the part of the gynecologist to have a broad general surgical background.

The chapter on "Bones and Joints" is written by several outstanding orthopedists and this chapter is noteworthy for its clarity and the excellence of its illustrations.

The inclusion of all the disorders of the hand in a single chapter entitled "Surgery of the Hand" is a departure from the previous text and indicates the growing importance of surgery of the hand in our

[1]CHRISTOPHER'S TEXTBOOK OF SURGERY. Edited by Loyal Davis, M.D. 6th ed. 1484 pages, 1359 illustrations on 716 figures. $15.50. Philadelphia and London: W. B. Saunders Co., 1956.

highly industrialized society. To this chapter, Michael Mason brings the wealth of his experience and that of his associates and predecessors including Dr. Koch, Dr. Bunnell, and the renowned Dr. Kanavel. This is an outstanding chapter in its completeness and the fundamental approach to the problems involving the hand.

This new textbook is an improvement on an already outstanding work. It covers the field of surgery, as well, perhaps, as this enormous subject can be encompassed by a single volume. —*Joel W. Baker.*

EVERY ONCE IN A WHILE one finds a text which provides a clear, concise, and complete procedure of management for any problem in its sphere. *Operative Technic in Specialty Surgery*[2] is such a book. It is devoted to the surgical specialties but contains much that overlaps the field of general surgery. The specialties covered include cardiovascular, thoracic, orthopedic, neurologic, plastic, gynecologic, and urologic surgery.

The editor, Warren H. Cole, has chosen an outstanding group of 32 authors. Each of them has had training in general surgery and each has contributed an up-to-date section on his particular field. Obsolete procedures have been omitted. Each author gives a clear description of the procedure he has found to be most effective for each lesion or problem. Many of the illustrations are reproduced on a larger scale than is customary which adds a great deal to their clarity.

The first chapter is devoted to the treatment of vascular injuries, aneurysm, arteriovenous fistula, occlusive arterial disease, varicose veins, and venous thrombosis. The next 3 chapters encompass the operative technique for lesions of the heart, pericardium, and great vessels, with an excellent section on cardiac arrest and resuscitation.

Chapter 5 presents the surgical management of mitral stenosis. The present status of surgery for mitral insufficiency and aortic commissurotomy is considered in some detail.

Chapter 6 covers the surgery of portal hypertension and includes an excellent discussion of relative merits of various operative procedures.

Chapter 7 is devoted to the thoracic wall, pleural cavity, and lungs. In addition to the surgical techniques one might expect to find for the management of lesions of these parts of the body, there is a section on both the transabdominal and transthoracic repair of diaphragmatic hernia and another on the surgical approach to mediastinal tumors.

Chapter 8 reviews maxillofacial surgery and surgery of neck lesions including neck dissection. Following this there is a chapter on plastic surgery.

The next 3 chapters on orthopedic surgery describe the treatment of fractures, osteomyelitis, and deformities and neoplasms of bone. Following this subject is an excellent and well illustrated chapter in which the author describes in detail the surgical approach to the major joints of the extremities. Chapter 14 discusses the orthopedic surgical treatment for spastic paralysis and the surgical treatment of poliomyelitis.

Five chapters are concerned with neurosurgery and explain the surgical techniques available for the autonomic nervous system and for lesions of the peripheral nerves, the skull and brain, the spinal cord, and the cranial nerves.

Chapter 20 is devoted to gynecologic surgery and is followed by a final chapter on surgery of the male genitourinary system.

The reviewer is impressed with the wealth of practical material that has been confined within one volume. This book will be one of the most valuable books in a general surgeon's library. —*Edward W. Gibbs.*

BEAUTIFULLY PRINTED and well illustrated describes the monograph entitled *The Cellular Basis of Wound Repair*.[3] The author, Martin Allgöwer, believes the role of the mononuclear cells in the formation of granulations in the wound has been underestimated. "The necessity for a clarification of the quantitative participation of hematologic mononuclear elements in experimental wound repair" becomes his objective. He approaches his mission by: (1) reporting correlation of mitotic activity and the concentration of cells in 1 to 8 day old rabbit ear wounds; (2) testing the ability of small protected areas to build granulation tissue in irradiated, leucopenic animals; (3) observing wound repair in isolated perfused ears; (4) comparing different tissues in culture to determine the extent to which various elements are able to imitate forms recognized within granulation tissue; (5) observing the effect of leucotactic and growth promoting substances on experimental wounds.

His results and what he accomplished toward the objective are best summarized by quoting the author's own summary. "The experiments presented give no definite indication as to which of the blood cells are capable of producing connective tissue. It appears improbable that monocytes are the only elements involved. Experiments on isolated perfused ears and quantitative aspects of wound repair have added no positive or negative evidence to this problem." In addition, it should be added that the cellular basis of endothelial and epithelial repair is very much neglected in this book. —*Edward L. Howes.*

IT IS ALREADY EVIDENT that *Clinical Recognition and Management of Disturbances of Body Fluids*[4] will be even more valuable than John H. Bland's first book, *The Clinical Use of Fluid and Electrolyte*. This new book is labeled second edition, but in reality it is a completely rewritten volume, not only dealing with the fluid and electrolyte problem in the severely ill patient, but covering the entire pathologic physiology involved in a particular problem.

This second edition is by no means a handbook encumbered with numerous charts and graphs. It is a fine textbook, not only going into detail where indicated, but in being aimed at the medical student and resident, as well as the practicing physician, it covers

[2]OPERATIVE TECHNIC IN SPECIALTY SURGERY. Edited by Warren H. Cole, M.D., F.A.C.S. With 67 contributing authors. 2nd ed. Introduction by Allen O. Whipple. 967 pages, illustrated. $20.00. New York: Appleton-Century-Crofts, Inc., 1956.

[3]THE CELLULAR BASIS OF WOUND REPAIR. By Martin Allgöwer, M.D. 125 pages, 45 illustrations. Springfield, Ill.: Charles C Thomas, 1956.

[4]CLINICAL RECOGNITION AND MANAGEMENT OF DISTURBANCES OF BODY FLUIDS. By John H. Bland, M.D. 2nd ed. 522 pages, 109 illustrations. $11.50. Philadelphia and London: W. B. Saunders Co., 1956.

the basic fundamentals of fluid and electrolyte metabolism. John Bland has obviously not slanted his book toward any particular medical group, believing that such metabolic problems should be the concern of all physicians who deal with significantly ill patients.

An effort is made to clarify terms dealing with the problems of water and electrolyte metabolism as they can compound the already dense confusion surrounding this field. It is believed that a standard terminology should be used, and this is well set up. The term hydrogen ion control has been introduced to replace acid-base balance as these substances are not actually acids or bases and do not exist on a teeter-totter, maintaining a certain balance and being abnormal when this balance is lost.

The chapter on surgical metabolism is very well written and will be of use to surgeons of all categories. This chapter was edited by Francis Moore and by Albert Mackay, Professor of Surgery at the University of Vermont.

The chapters dealing with metabolic abnormalities produced by head injury and central nervous system disease are not available elsewhere.

At present Doctor Bland is Associate Professor of Medicine at the University of Vermont. He should receive great credit for producing a book which will be useful to all branches of the medical profession.

—*Philip H. Davis.*

Doctor Phelps, an authority on cerebral palsy and body mechanics, Professor Kiphuth, an expert on physical education, and Doctor Goff, an authority on posture, have combined their knowledge and experience to produce a most stimulating book entitled *The Diagnosis and Treatment of Postural Defects*.[5] The material is pertinent to physicians, physical educators, and athletic coaches.

The authors believe that the evolutionary influences are of great significance in the posture of man and discuss this subject in the first chapter. The chapter, "Environmental Influences," indicates that man's posture is conditioned by his activities which are related to cultural demands. They further point out that there are many variations in body structure. They refer to Wolff's law which states that the structure of the bone of the adult is related to the internal and external architectural stresses. They recognize that the force of gravity exerts an influence upon posture. Overfeeding with liquid foods in childhood causes slack abdominal muscles and these in turn have a serious influence on the posture of the child. As the child learns to sit and stand it develops the strength in the muscles required for these functions. Bow legs, knock knees, and slack heel cords may thus be normal variants of the lower extremity posture and require no special corrective measures unless present in a marked degree.

The adolescent variations and the importance of overcoming self-consciousness and its accompanying awkwardness are discussed. Youths who are slow maturing should be restricted in their exercises, particularly in contact sports.

The authors find normal posture difficult to define. For them it is the average or mean of a large number of postural studies. They point out that this mean posture is certainly not the ideal. They believe that posture can be improved by education and training, and emphasize the importance of organized sports programs. Exercises which will bring about improvement in posture are described.

The book is well illustrated with photographs and line drawings.

—*Emil D. W. Hauser.*

The monograph, *Tumors of the Skin*[6] by Herbert Conway, is a book that has been needed for many years by the surgical house officer, the general surgeon, and the surgeon concentrating in a specialty. The lessons to be learned from this book should encourage the physician or surgeon who falters in the treatment of tumors of the skin because of fear of scars or disfigurement to re-evaluate the less effective and often dangerous methods used all too frequently today. For example, in chapter 6 on "Nevi," the author writes: "About half of the patients coming to treatment for melanoma report the previous treatment of a mole, usually by electro-desiccation or by some other method which may not insure complete destruction or removal." In chapter 14, on "Carcinoma of the Skin," he writes: "The ease of application of x-ray therapy poses a temptation to employ it as a trial without accurate preliminary diagnosis"; and "Recurrent lesions, regardless of the method of primary treatment, usually do not respond favorably to radiation." Throughout the book he emphasizes that "surgical treatment, in order to be of maximal usefulness, must be employed not only as an excisional technique but also as a reconstructive technique."

Each of the skin tumors presented, from those most commonly encountered to the most bizarre and obscure, is discussed carefully from the points of view of its clinical and pathologic characteristics, frequency of occurrence, choice of treatment, and late results. A well selected short bibliography for ready reference is added after each discussion.

Perhaps the most stimulating features of the book are the demonstrations of most tumors by photographs, the drawings of the application of plastic surgical principles and methods of treatment, and the high standard of acceptable surgical results.

How many surgeons practice the technique of excision of a tumor in the substance of the eyebrow illustrated on page 74, or the techniques of rotated, interpolated, or advancement flaps illustrated on pages 182 to 189? The surgeon who is unfamiliar with the application of these and other techniques, skimps in the removal of benign or malignant tumors, produces cosmetic and functional disabilities, and has recurrences in the scar, any one of which prejudices the profession against the most effective treatment which today is surgical.

Tumors of the Skin should find a place in the hospital library for reference by the puzzled house officer, on the young surgeon's bookshelf, because much of his practice in the early years will be concerned with

[5] The Diagnosis and Treatment of Postural Defects. By Winthrop Morgan Phelps, M.D., Robert J. H. Kiphuth, M.P.E., and Charles Weer Goff, M.D. 2nd ed. 190 pages, 87 illustrations. $6.50. Springfield, Ill.: Charles C Thomas, 1956.

[6] Tumors of the Skin. By Herbert Conway, B.S., M.S., M.B., M.D., F.A.C.S. 267 pages, 178 illustrations. $13.50. Springfield, Ill.: Charles C Thomas, 1956.

these lesions, and in the hands of the radiologist, the physician, and the dermatologist, many of whom may be unfamiliar with these lesions and unable to choose the most effective and least dangerous method of treatment. All will profit by a familiarity with the possibilities of reconstructive techniques.

—*Bradford Cannon.*

PUBLISHED UNDER THE AUSPICES of the Society for the Problems of Brain Injury (West Germany), the book entitled *Das Hirntrauma*[1] is a compilation of the observations and opinions of over 50 currently practicing German physicians, neurosurgeons, neurologists, psychiatrists, pediatricians, anatomists, and experts in forensic medicine.

The 10 chapters constituting the book are divided into from 3 to 11 sections, each being written by a different author. While the book certainly is not lacking in detailed discussion, yet there is a disparity in the detail allowed for various subjects, apparently depending upon the desire of the author to express his thoughts concisely and succinctly. Some sections contain but 5 pages, such as the opening one by Tönnis, in the discussion of recent closed head injuries; other sections, dealing with specific diagnostic methods, may occupy 35 pages. Some of the sections are previously delivered lectures by the authors. Thus the book suffers a defect common in many such compilations from numerous authors, in the imbalance that comes from overtreatment and undertreatment of various subjects and the discontinuity of subject matter. Yet the over-all effect of the book is impressive, the expressed opinions carry strong convictions, and the authors are men who are of importance in current German medicine.

[1]DAS HIRNTRAUMA; BEITRÄGE ZUR BEHANDLUNG, BEGUTACHTUNG UND BETREUUNG HIRNVERLETZTER. By Dr. Med. E. Rehwald. Stuttgart: Georg Thieme Verlag, 1956.

Recent and old, open and closed, surgical and nonsurgical types of head injury are reviewed, and throughout the book special emphasis is placed on the total effect of the injury on the patient insofar as his effective role in society is concerned. Together with detailed discussions of the microanatomic changes in the architectonics of the different lobes of the brain, there is much said concerning the vegetative changes which follow hypothalamic and brain stem wounding. The use of electroencephalography, pneumencephalography, and arteriography is extensively treated, and the discussions are well illustrated, but there is nothing new presented here which is not already in use in most neurologic clinics. Old terms, such as "commotio cerebri" and "contusio cerebri" are freely used. The late onset of posttraumatic epilepsy is recognized as a still unsolved problem. The book is noteworthy for the absence of individual case reports.

The sociologic aspects of brain injury are considered very far reaching, and the authors point out that it is important, but often difficult, to differentiate between original basic personality defect and original criminal tendency, and the psychologic changes which brain injury may produce to lead to criminality. Manslaughter, sexual deviations of various sorts, combativeness and aggressiveness, burglary, and other forms of criminality are commonly found in the brain injured subject, the injury in some instances having been of the closed type, years previously, and overlooked as the origin of the individual's criminal tendencies. Injury to the frontal and temporal lobes especially produce such defections. The pleas are made that the courts become more aware of all the manifestations of brain injury which may play a role in criminal action.

The book is well printed; the illustrations, though not numerous, are of excellent quality, there is an adequate index, and there are abundant references to the world literature. —*John Martin.*

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

KLINISCHE FUNKTIONSDIAGNOSTIK. By Doz. Dr. Heinrich Küchmeister, Prof. Dr. W. Bolt, Prof. Dr. H. Goldeck, and Dr. H. Hamm. 411 pages, 152 illustrations. DM 49.50. Stuttgart: Georg Thieme Verlag, 1956.

AN INTRODUCTION TO ELECTROCARDIOGRAPHY. By L. Schamroth, M.B., B.Ch.(Rand.), M.R.C.P.E., F.R.F.P.S. 60 pages, 106 illustrations. Price, 21/—. Cape Town and Johannesburg: Juta & Co. Limited, 1956.

LE COEUR PULMONAIRE AIGU DANS L'EMBOLIE PULMONAIRE. By A. Tourniaire, M. Tartulier, F. Deyrieux, and J. Blum. With the collaboration of Pierre Marion. Preface by Prof. R. Leriche. 190 pages, 66 illustrations. 3.700 fr. Paris: Expansion Scientifique Française, 1956.

OBSERVAÇÕES ANATÔMICAS SOBRE O NERVO MASSETÉRICO. Sua aplicação à técnica da mioplastia com m. masseter no tratamento da paralisia facial. By Paulo de Castro Correia. Tese para concurso de Docência Livre de Clínica Cirúrgica, apresentada à Faculdade de Medicina da Universidade de São Paulo. 80 pages, 11 illustrations. São Paulo, 1954.

SURGERY OF THE HAND. By Sterling Bunnell, M.D. 3rd ed. 1079 pages, 1047 illustrations and 9 color plates. $22.50. Philadelphia and Montreal: J. B. Lippincott Co., 1956.

TUMORI DEL TESSUTO ADIPOSO. By Manilio Caucci. Preface by Prof. G. Gherardo Forni. 242 pages, 61 illustrations. Bologna: Licinio Cappelli Editore, 1955.

THE MORALITY OF HYSTERECTOMY OPERATIONS. By Rev. Nicholas Kohkamp, O.F.M., S.T.L. A Dissertation Submitted to the Faculty of the School of Sacred Theology of the Catholic University of America in Partial Fulfillment of the Requirements for the Degree of Doctor of Sacred Theology. 206 pages. $2.25. Washington, D. C.: The Catholic University of America Press, 1956.

ESSENTIAL UROLOGY. By Fletcher H. Colby, M.D. 3rd ed. 656 pages, 357 illustrations. $8.00. Baltimore: The Williams & Wilkins Co., 1956.

THE SPINE; ANATOMICO-RADIOGRAPHIC STUDIES DEVELOPMENT AND THE CERVICAL REGION. By Lee A. Hadley, M.D. 156 pages, illustrated. $6.50. Springfield, Ill.: Charles C Thomas, 1956.

NATURAL CHILDBIRTH. By H. B. Atlee, M.D., F.R.C.S. (Ed. & Can.), F.I.C.S. 79 pages, 8 illustrations. $2.75. Springfield, Ill.: Charles C Thomas, 1956.

AIDS TO EMBRYOLOGY. By J. S. Baxter, M.A., M.Sc., M.D., F.R.C.S.I. 5th ed. 196 pages, 61 illustrations. $2.50. Baltimore: The Williams & Wilkins Co.; London: Baillière, Tindall and Cox, 1956.

J. A. M. A. QUERIES AND MINOR NOTES. Published for the American Medical Association. 334 pages. $5.50. St. Louis: The C. V. Mosby Co., 1956.

CLINICAL UROLOGY FOR GENERAL PRACTICE. By Justin J. Cordonnier, M.D., F.A.C.S. 252 pages, 47 illustrations. $6.75. St. Louis: The C. V. Mosby Co., 1956.

PROCEEDINGS; WORLD CONGRESS OF ANESTHESIOLOGISTS, SCHEVENINGEN, THE NETHERLANDS, SEPTEMBER 5–10, 1955. Edited and published by the International Anesthesia Research Society. 321 pages, illustrations. Minneapolis, Minn.: Burgess Publishing Company, 1956.

CANCER OF THE ESOPHAGUS AND THE STOMACH. By Owen H. Wangensteen, M.D., F. A. C. S. 2nd ed. 144 pages, 60 illustrations. New York: American Cancer Society, Inc., 1956.

J. A. M. A. CLINICAL ABSTRACTS OF DIAGNOSIS AND TREATMENT. Published with the Approval of the Board of Trustees, American Medical Association. 661 pages. $5.50. New York and London: Intercontinental Medical Book Corp., with Grune & Stratton, Inc., 1956.

SURGICAL FORUM; PROCEEDINGS OF THE FORUM SESSIONS FORTY-FIRST CLINICAL CONGRESS OF THE AMERICAN COLLEGE OF SURGEONS, CHICAGO, ILLINOIS, NOVEMBER 1955. Vol. VI. 654 pages, illustrated. $5.00. Chicago: American College of Surgeons, 1956.

SURGERY FOR GENERAL PRACTICE. By Victor Richards, M.D. 947 pages, 476 illustrations. $17.50. St. Louis: The C. V. Mosby Co., 1956.

CANCER OF THE LUNG; AN EVALUATION OF THE PROBLEM. Proceedings of the Scientific Session, Annual Meeting, American Cancer Society, Inc., November 3–4, 1953. 322 pages, illustrated. New York: American Cancer Society, Inc., 1956.

NEW BASES OF ELECTROCARDIOGRAPHY. By Demetrio Sodi-Pallares, M.D. With the collaboration of Royall M. Calder, M.D., Editor, English Translation. 727 pages, 523 illustrations. $18.50. St. Louis: The C. V. Mosby Co., 1956.

HEAD INJURIES AND THEIR MANAGEMENT. By Francis Asbury Echlin, M.D., C.M., M.Sc., Med.Sc.D., F.A.C.S. 127 pages, 10 illustrations. $3.00. Philadelphia and Montreal: J. B. Lippincott Co., 1956.

THIOPENTONE AND OTHER THIOBARBITURATES. By John W. Dundee, M.D., F.F.A.R.C.S., D.A. 312 pages, 59 illustrations. $5.00. Baltimore: The Williams & Wilkins Co.; Edinburgh and London: E. & S. Livingstone Ltd., 1956.

CLINICAL REPORT OF THE DEPARTMENT OF OBSTETRICS, UNIVERSITY COLLEGE, IBADAN, NIGERIA. April 1st, 1953-December 31st, 1954. By J. B. Lawson, M.A. (Cantab.), M.B., B.Chir., M.R.C.O.G., and U. G. Lister, M.B., B.S.(Lond.), M.R.C.O.G. 170 pages, 2 illustrations. London: Vail & Co., Ltd., Printers, 1955.

SIR JOHN BLAND-SUTTON, 1855–1936. By W. R. Bett, M.R.C.S. (Eng.). Foreword by Lord Webb-Johnson. 100 pages, 5 illustrations. $4.75. Baltimore: The Williams & Wilkins Co.; Edinburgh and London: E. & S. Livingstone Ltd., 1956.

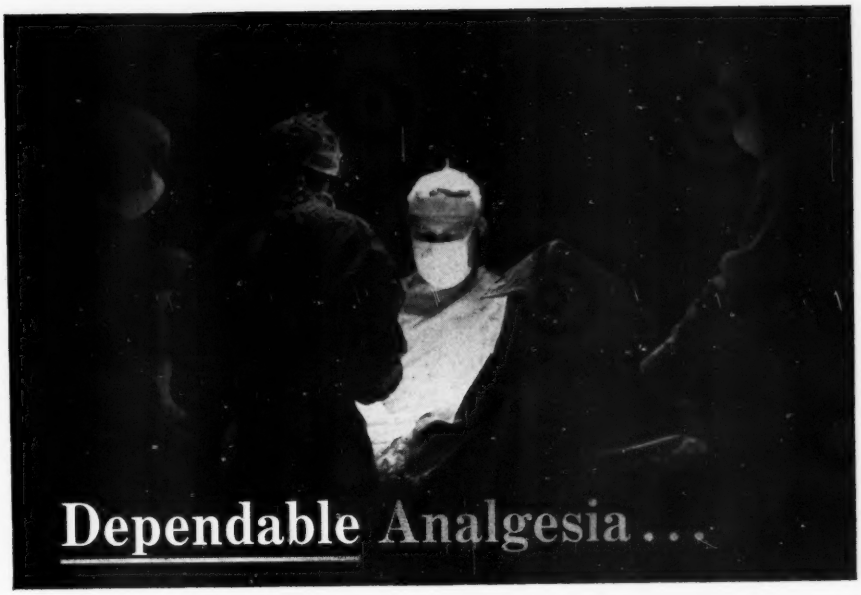
TUMORES DEL PÁNCREAS. By Dr. Manuel A. Casal. 179 pages, 18 illustrations. Buenos Aires: Editorial Aecius, 1956.

Correspondence

EDMUND BROWN PIPER AND HIS FORCEPS FOR THE AFTERCOMING HEAD—

A Correction.

DR. HAROLD SPEERT wishes us to call attention to the fact that in his article which appeared in the September issue of the Journal, on page 367, he incorrectly used "Edward" in the title instead of "Edmund" Brown Piper.



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